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Science and the Nation.

By the Rt. Hon. S. M. Bruce, P.C., M.C., Prime Minister of Australia.

The part played by scientific research as one of the factors of the welfare of nations, and, in fact, as the foundation of the whole fabric of modern society, is nowadays so widely recognized that it need hardly be elaborated here. It would, perhaps, be sufficient to note one or two outstanding recent examples, such as the enormous and world-wide development of radio based entirely on what, at first sight, seemed to be unimportant laboratory experiments. As an instance of what science has done in the direction of the reinforcement of human effort by mechanical appliances, attention might be drawn to the United States, where energy to the extent of 60 man-power per head is now available, or, in other words, where every man, woman, and child is provided with the equivalent of 60 slaves of olden times. This fact is not without significance in connexion with the undoubted capacity of America to maintain an enormous population in great comfort, and also to absorb a large and continuous stream of immigration.

The example of Germany in the field of scientific research has been quoted so often that it has become a commonplace. But it needed the outbreak of the recent war to make the whole world realize how efficient German industries, particularly those based on the science of chemistry, had become.

Since the war important research developments have taken place in practically every country, and there is no doubt that these national efforts will have an enormous and far-reaching effect. In some cases, in fact, that effect has already been felt. Moreover, it is becoming abundantly clear that no country that desires to carry out its development on the most modern and efficient lines can afford to neglect the fostering of scientific effort within its borders. This idea was well expressed in the following words of the Research Committee of the recent Imperial Economic Conference:—

"Money devoted to research is not a luxury; it is not merely a sound investment; it is rather a condition of survival without which the Empire cannot hope to keep abreast of its competitors in the economic field."

As with countries, so with individual industries it is widely recognized that the newer intensive application of scientific methods gives results of such far-reaching value that no industrial activity can hope to ignore research and meet with success.

In any consideration of the extent to which the value of applied science is realized in other countries, it is pertinent to recall a few of the outstanding efforts that have been made. Naturally these have been in connexion with the more important industries of the particular countries concerned. Thus, in Great Britain, the Department of Scientific and Industrial Research has been established, and has been provided with a capital fund of £1,000,000, and an annual budget in the neighbourhood of £500,000. It will cater mainly for the needs of manufacturing industries. Agriculture also has not been overlooked, and the Development Commission has been provided with a fund of £1,000,000, and a large annual vote for the encouragement of research in agriculture. A still more recent development is the establishment of the Empire Marketing Board, which will control an income of £1,000,000 per annum, and of this, 15 per cent. or more will be set aside for the purposes of research into the production, preservation, and storage of foods throughout the Empire.

Turning to the United States, the work of the Carnegie Institute with its capital endowment of £4,000,000, of the Bureau of Standards with an annual budget of £120,000, of the Bureau of Mines which annually expends £100,000 for research, of the magnificent private industrial research laboratories with which America is so richly endowed, is well known. It is perhaps not so well known that the United States Department of Agriculture has an annual appropriation of £8,000,000, of which £2,000,000 is spent on research alone.

Reverting to Empire activities, Canada has established an Advisory Council of Scientific and Industrial Research; New Zealand has done likewise; and South Africa has already made great progress in the scientific investigation of her primary industries. In particular, her magnificent Veterinary Station at Onderstepoort, with its capital fund of £250,000, and its annual appropriation of £100,000, might well be mentioned.

Turning to Australia, it is only too evident that, on the one hand, an extraordinary number of important and national problems exist, and, on the other, that a relatively small personnel is available with which to investigate them. The rapid spread of imported pests, such as prickly pear, rabbits, and blowflies, when removed from their natural habitat and from the factors that there contrived to keep them in control, is amazing. The breeding of plants of economic value capable of being grown in the drier parts of the continent, the development of methods whereby greater quantities of Australian-grown perishable foods can be placed on the outside markets of the world, means whereby a local supply of internal combustion engine fuels may be evolved, and many such matters constitute other groups of problems that exist, not only in one State of the Commonwealth, but in every State. Much work in regard to many of these problems has been carried out, and in this connexion a tribute is due to the magnificent efforts that have been made by State Departments of Agriculture, of Mines, of Forests, &c., and of the various Australian Universities. Nevertheless, it has become quite clear that if our splendid opportunities are to be fully realized, and our high standard of living to be improved or even maintained, the Australian effort in the field of scientific research must be intensified.

Some twelve months ago the Government accordingly decided to place the Council for Scientific and Industrial Research on a proper and

effective footing, and it is pleasing to be able to record that that action received the general commendation of every party in the Federal Parliament, as well as approval and co-operation from many outside organizations.

In order to ensure that the Council will start well, and that, at any rate for the first few years of its existence, it will not be seriously handicapped by any conditions of financial stress that may arise, a Trust Fund of £250,000 has been put aside for its use. It is intended that this amount will suffice for two or three years, but at the end of that time it may confidently be expected that the Council's achievements will amply warrant the setting aside of further funds for future years. It is not intended that the Council should in any way duplicate the functions of existing institutions. On the contrary, it has been established for the express purpose of co-operating with such organizations to the fullest possible extent. Many of the investigations to be initiated will be carried out in the existing laboratories of Universities, State Departments of Agriculture, &c. At the same time it is recognized that such a procedure will not always be possible, and that it will be necessary to proceed by independent efforts in many directions, where problems are more national in character. Another very important function of the Council will be to act as the agent whereby liaison and a full and fruitful form of co-operation may be established with similar bodies in other parts of the world. Co-operation in the field of defence has been immensely beneficial to all parts of the Empire, and, so far as Australia is concerned, it has ensured our economic independence and our national safety. Co-operation in times of peace is, perhaps, as necessary as in times of war, and the new move for the co-ordination of scientific efforts throughout the Homeland, the results of which will be freely available to us, will, it is confidently anticipated, ensure a steady improvement of conditions throughout the Empire.

On the manufacturing side, the Council will, to the greatest possible extent, co-operate with the British Department of Scientific and Industrial Research. That co-operation will be facilitated by the fact that the Council has been given a constitution very much in accord with recommendations made by the Secretary of the British Department, Sir Frank Heath, who, on the invitation of the Government, recently visited Australia, and made himself familiar with local conditions. On the agricultural side, the Imperial Conference on the Co-ordination of Agricultural Research, which is to be held in October, 1927, and which has been convened for the purpose of considering machinery whereby an active form of co-operation may be brought into being between all parts of the Empire, will, it is hoped, enable the Council to commence its Empire co-operative work almost at once.

Another matter to which the Government has given considerable thought and attention is that of the training of research workers. It has become abundantly clear that, in some directions, notably in those of the biological sciences, Australia, and, for that matter, the Empire, is sadly lacking in research personnel. In order that this position may be overcome, and as a safeguard against its arising in the future, the Government has put aside the sum of £100,000 in a special Trust Fund. The interest earned by this Fund will be devoted entirely to the purposes of providing assistance to persons engaged in scientific research and in the training of research students.

In the light of the efforts which are being made in other countries in the direction of industrial research work, there does not seem to be any question but that Australia must realize the tremendous importance of this branch of industry, and by a closer study of the factors affecting each particular industry ensure that her commercial success shall be assured. At the present time, there is undoubtedly a great dearth of capable research personnel available. I would suggest that this may be largely accounted for by the limited amount of research work which has been carried out by Australian industry up to date.

The Council has been placed under the control of a full Council, consisting of an Executive of three members, and the Chairmen of Committees which have been formed in every State. Other members will be co-opted when considered desirable. The full Council will meet at approximately six monthly intervals, and between its meetings the Executive Committee takes control. The personnel of the Council and the Executive has been so chosen as to form a well-balanced team representative of business, primary industries, secondary industries, and science in general. The election of the personnel for the State Committees has been left more or less in the hands of the State Governments and other State interests, but here again the team idea has been adopted.

After a year's operation, the Council finds that, from time to time, it receives valuable reports from its State Committees, Special Committees, and from other authorities. It considers that nothing but good can arise out of the circulation of many of these reports much more extensively than has been the case in the past. It also feels that a medium whereby it can acquaint the Australian people with exactly what it is doing would be of value. It has, therefore, been decided to publish this Journal, which both the Government and the Council hope will be a means whereby a wider knowledge of our national problems, and of what is being done to overcome them, may be disseminated throughout the Commonwealth.

Science and Labour.

By M. Charlton, M.P., Leader of the Opposition, Commonwealth Parliament.

Knowledge has very often and very aptly been compared to a torch passed from hand to hand. Very little advance could be made even by the greatest man of science if he were dependent upon what knowledge he might acquire from his own personal observations. During the centuries which preceded the dawn of experimental science, a vast mass of traditional knowledge was accumulated by our ancestors. But the rate of progress in man's command over nature and in the development of new industries was in those days painfully slow.

Since the Industrial Revolution, however, we have seen a whole succession of fundamental discoveries in science, resulting in the establishment of innumerable new industries and in revolutionary changes in the habits of man. During the past 150 years, the progress made in man's command over nature has been immeasurably greater than in all preceding years.

The changes in recent times in land transport, in sea traffic, in manufacture, in the transmission of messages—all due to fundamental discoveries in science—tell the same story of a series of economic and social changes, rapidly superimposed one on another.

Less than a century ago, new scientific inventions caused such grave misgivings to labour as to induce the workers to wreck the new machines by which they thought their livelihood was endangered. That mistrust has now given place to a spirit of sympathy and co-operation with the progress of science in all departments of human thought and endeavour. Both labour and scientific research are working for progress, for the development of the human race, and for the maintenance of the people in efficiency and comfort. Science is the creator of knowledge; the inventor is the applier of knowledge gained in the laboratory; the artisan is the user of that knowledge in working machines and implements, new processes, and materials. In those three—science, invention, and labour—we have the foundation on which we can build a noble superstructure in the future.

Of the three main types of government—autocracy, aristocracy, and democracy—it is especially the democratic form of government that obviously depends most on the fullest possible development and utilization of science. Certainly labour has no belief in any of the problems being solved by goodwill alone. Labour stands for the acquisition of new knowledge, the organization of research on national problems, the fostering of the scientific spirit, and the more intensive dissemination among the whole people of the experience so obtained.

Science has lifted labour to a higher level. It has reduced the cost of production, and has brought the commodities of life within the reach of many who could not otherwise have afforded them, thus creating a further demand for labour to produce them. Any new knowledge, any discovery which leads to the control of the forces of nature, the development of new industries, or the improvement of existing industries, is bound to create employment and new wealth, and must be for the benefit of labour. Shorter hours have alone been possible because more could be produced in a given time. From the consumers' point of view—and every worker is a consumer—scientific research has resulted in an improved standard of living.

One of the striking developments of the past few years is the recognition by Governments of the fundamental importance of research, and the creation of scientific industrial research institutions on a national basis. In that movement, Australia has played her part in establishing the Council for Scientific and Industrial Research. Scientific research is an instrument of almost unlimited potentialities in connexion with the problems of increased production, and of the improvement of the condition of the workers. It is the basis of the increase in the productivity of labour, and of practically all the conveniences which the people enjoy to-day. Nor can the importance of pure science be overlooked. Every fundamental discovery has originated in the laboratory devoted to pure science without any immediate regard to its practical application. The discoveries of Faraday were all made in the laboratory, and were believed originally to be of no practical importance; yet in his discoveries lay the germ of all the dynamos and the great systems of electric power transmission of the present day, including electric railways and tramways, without which modern transport

would be impossible. The researches of Pasteur were commenced entirely from the point of view of pure science, and it was only later that he took up the application of the results, first to fermentation problems, and then to the control of disease. The discovery of electric waves, which now broadcast information and entertainment over the earth, arose from a mathematical investigation by Clerk-Maxwell, and it took twenty years to bring these waves out of the realm of mathematical formulae into the realization of fact. The discoveries in heredity and cross-breeding which were made initially by Mendel, and which have added millions to Australia's wealth, initially had no industrial objective in view. All these, and innumerable other fundamental discoveries, have re-acted in an extraordinarily favorable way on the well-being and comfort of the worker.

Science knows no boundaries, no creeds, and no political parties. It is the basis of practically all advance in economic and social conditions. All nations contribute in forwarding the general interests, and in adding to our scientific knowledge. Accordingly research tends to increase mutual respect, and cannot fail to enhance faith in human progress and goodwill between nations. In its broader aspects the application of scientific research holds out prospects of great achievement. It promises the intelligent development of our natural resources; an increased production from our agricultural and pastoral industries, and the control and eradication of many of the pests and diseases which now afflict them; the economic utilization of our forests, and of our forest and mill waste; the efficient control of processes of production in our manufacturing industries; the development of new industries; and an increased production which will react beneficially on all sections of the community. The Commonwealth is coming to a critical stage in its industrial and economic development, and our future well-being depends largely on the way in which science is applied to our industries, and to the efforts which we make in carrying out scientific research for the solution of our problems. We are to-day witnessing a revolution from rule-of-thumb methods to those of scientific control and direction. Our national policy must be directed to make this inevitable change, and thus to help Australian industries. One of the main difficulties to be overcome is the creation in the community of a recognition of the importance of scientific research, and of an atmosphere which will encourage research in all departments of knowledge. It is believed that the publication of this Journal will assist materially in overcoming that difficulty.

The Council for Scientific and Industrial Research: Its Organization and Work.

By Senator the Rt. Hon. Sir George F. Pearce, P.C., K.C.V.O., Vice-President of the Executive Council.

1. The Council.

In 1926 steps were taken by the Commonwealth Government for the re-organization of the Institute of Science and Industry, which had been established by an Act passed in 1920. The main object of the *Science and Industry Research Act* 1926 was to obviate two main difficulties which had existed previously, viz., (1) a scheme of control which was somewhat too centralized; and (2) lack of necessary funds. By the *Science and Industry Research Act* 1920-1926, the control of the Commonwealth's activities in the field of scientific and industrial research was placed in the hands of a Council, which is a corporate body consisting of:—

(*a*) Three members nominated by the Commonwealth Government (one being Chairman), and appointed by the Governor-General.

(*b*) The Chairman of each State Committee of the Council.

(*c*) Other members co-opted by reason of their scientific knowledge.

Provision was made for the co-option of members in order to permit of the inclusion in the Council of representatives of important fields of science and industry, who might otherwise have been omitted. The Act provides that the Council shall meet at such times and places as the Minister determines. Owing to the difficulty in arranging for the attendance of members at frequent meetings of the Council, and to the expense which would thus be involved, there is an Executive Committee which consists of the three members nominated by the Commonwealth Government, and which exercises, between meetings of the full Council, all the powers and functions of the Council.

2. The State Committees.

An important feature of the Act is the provision made for the appointment of State Committees, whose main functions are to advise the Council regarding the general business of the Council, and any particular matter of investigation and research. Regulations have been prescribed under the Act providing that each of these Committees shall consist of a Chairman selected by the Commonwealth Government; three members nominated by the State Government from the staffs of its scientific departments; and three members, eminent in science, of whom at least two shall be members of the staff of the local University,

all three being nominated by the Australian National Research Council. In addition, the Chairman and the six members thus appointed have the right to nominate three members associated with industry, while further members, not exceeding six, may be co-opted by reason of their special qualifications, with the consent of the Executive Committee.

3. Powers and Functions of the Council.

The powers and functions of the Council as defined by the Act are as follow:—

(*a*) The initiation and carrying out of scientific researches in connexion with, or for the promotion of, primary or secondary industries in the Commonwealth.

(*b*) The training of research workers and the establishment and awarding of industrial research studentships and fellowships.

(*c*) The making of grants in aid of pure scientific research.

(*d*) The recognition or establishment of associations of persons engaged in any industry or industries for the purpose of carrying out industrial scientific research, and the co-operation with and the making of grants to such associations when recognized or established.

(*e*) The testing and standardization of scientific apparatus and instruments, and the carrying out of scientific investigations connected with standardization of apparatus, machinery, materials, and instruments used in industry.

(*f*) The establishment of a Bureau of Information for the collection and dissemination of information relating to scientific and technical matters.

It is also provided that the Council shall act as a means of liaison between the Commonwealth and other countries in matters of scientific research.

4. Co-operation with States.

The Council is intended to supplement, and not take the place of, existing scientific industrial research institutions and departments in the several States, and the Act specifically states that the Council shall, as far as possible, co-operate with existing State organizations in the co-ordination of scientific investigations with a view to—

(*a*) the prevention of unnecessary overlapping; and

(*b*) the utilization of facilities and staffs available in the States.

The Commonwealth Government desired to bring into being a real co-operation between all those engaged in applying science and research to industry. It is gratifying to know that the States have accepted this position, and that they are already co-operating whole-heartedly with the Council.

5. The Science and Industry Investigation Fund.

By the Act of 1926, a sum of £250,000 was appropriated for the purposes of scientific and industrial investigations carried out in pursuance of the Act. The appropriation of that sum, which has been paid into a Trust Account, obviates the necessity for Parliament being

asked to make annual votes for the purpose of the Council's work. Parliamentary control over the operations of the Council is effected by a clause in the Act providing that no money can be expended from the Trust Account except in accordance with Estimates passed by Parliament.

6. Appointment of Officers.

The Act empowers the Council to appoint officers with the approval of the Minister. Officers are not subject to the Commonwealth Public Service Act, but are engaged for such periods, and are paid such salaries and allowances, and are subject to such conditions as the Council with the approval of the Minister, determines. They are entitled to contribute to, and receive benefits under, the Commonwealth Superannuation Fund. Provision is made for the payment of bonuses in the case of discoveries or inventions being made by officers.

Whilst the work of the new Council has as yet, in many directions, hardly passed beyond its initial stages, the outline given in the following paragraphs of the more important activities of the Council suffice to show that a real move forward has been made, and that there is at least a reasonable expectation that future years will reveal a substantial record of achievement and success in the application of science to industry in the Commonwealth.

7. Preliminary Work.

Three series of meetings of the full Council have so far been held. The Executive Committee has held 59 meetings. At the early meetings both of the Council and the Executive Committee, a great deal of the time was necessarily devoted to initial matters of organization, and the procedure to be followed in promoting research work. At the first meeting of the Council, it was decided that efforts should for the present be concentrated primarily on the organization of research work in the following five main groups of problems:—

1. Animal pests and diseases.
2. Plant pests and diseases.
3. Fuel problems, especially liquid fuels.
4. Preservation of foodstuffs, especially cold storage.
5. Forest products.

Moreover, a considerable amount of time and attention had to be devoted to making a survey of the whole field of industrial research to ascertain the most pressing problems; their economic importance; what facilities in the way of laboratories, equipment, and staff were available; whether they were already being attacked by existing institutions; and, if so, in what way these efforts could best be supplemented.

In order to carry out this preliminary work efficiently, it was found necessary to secure the temporary and part-time services of persons who had special knowledge and experience in certain of the major branches of science and industry concerned. Thus, in regard to plant problems the services of Professor T. G. B. Osborn, Professor of Botany, Adelaide University, were obtained in order that he might visit each of the States, and collect definite information as to the problems, the centres at which research work is being conducted in the several States, the outstanding groups of problems on which work should be undertaken by the Council, and the most suitable methods of attack. Again, as regards animal diseases and pests, the services of

Professor H. A. Woodruff, Professor of Veterinary Pathology, Melbourne University, were secured. As will be seen from the following paragraphs, similar action has been taken in regard to certain other major lines of investigation. Whilst it is realized that this course, in some cases, involved considerable delay in the actual initiation of research work, it was considered essential to obtain authoritative information at first hand in order to enable the foundations for future operations to be laid securely.

A great deal of attention has been given by the Council to the possibility of initiating new researches on agricultural problems, and supplementing, where necessary, the admirable work of the State Departments. It was perfectly clear that, in this field perhaps more than in any other, close co-ordination was essential if overlapping and waste of effort were to be avoided. The Council therefore convened in March last an Agricultural Conference to advise it as to what place it could best fill in the field of agricultural research, and as to how it could best co-operate with the State Departments.

The Conference was attended by the Heads of each of the State Departments of Agriculture (each accompanied by one of his senior officers); by the Professors of Agriculture of the Australian Universities; by one or two other agricultural experts; and by representatives of the Council. It was of the opinion that, in view of the number and magnitude of the problems concerning the agricultural and live-stock industries of Australia, Commonwealth participation in agricultural research is desirable; that there are many problems which are national in range or scope, fundamental in character, and which require concentration, effort, and highly specialized research for their solution; and that such problems are specially suited for investigation by the Commonwealth. The Conference was also of the opinion that the Council could render a service to the agricultural institutions of the Commonwealth by acting as a clearing house for information on research projects in progress in State institutions and Universities, and that it could also render a service by issuing a Journal of Australian Scientific Research, which would afford a means for the publication of papers on agricultural subjects which are too technical for inclusion in State Departmental journals. The Conference considered that the way in which the Council could best serve Australia in the matter of agricultural advancement was by the establishment of a relationship of co-operation and collaboration with the State Departments of Agriculture, the Universities, and other institutions concerned with agriculture and live-stock interests. Throughout all the discussion that took place at the Conference, it was evident that the States would welcome the advent of the Council into agricultural research in certain important directions, and that they would be very willing to co-operate closely in that work.

In order to effect the desirable co-operation and collaboration between the Commonwealth and the State Departments, the Conference recommended that a Standing Committee on Agriculture should be appointed, consisting of the permanent Heads of the State Departments of Agriculture, and representatives of the Council, and that the functions of that Committee should be to act as the advisory and consultative body on matters relative to agricultural and live-stock research undertaken by the Commonwealth. The Standing Committee was duly appointed, and held its first meeting at Adelaide in May last.

As regards research on problems affecting manufacturing industries in Australia, the Council's principal activities are in connexion with paper pulp; the manufacture of tannin extracts; fuel problems, and especially liquid fuels; "synthetic" building stones; and the preservation of foodstuffs, especially cold-storage problems. The problems connected with our primary industries are, however, so numerous and pressing that it appears probable that, for some years, the principal work of the Council will lie in the field of biological research.

8. Investigations on Plant Problems.

One of the most important investigations on which the Council is engaged is the attack on the prickly pear pest, which covers an area of about 60,000,000 acres in New South Wales and Queensland, that is about three times the total area cultivated in Australia under all forms of crops. The object of the investigations is to ascertain the practicability of the control and eradication of the pest by biological means, i.e., the introduction of insect enemies and fungous diseases which destroy the pear in other countries. The work was initiated by the former Advisory Council of Science and Industry in co-operation with the New South Wales and Queensland Governments. Various species of insects have been acclimatized, and exhaustive tests have been carried out to ascertain whether they will attack any plant other than prickly pear. Under no circumstances is any species of insect liberated unless it passes all the tests. Moreover, there are many different kinds of prickly pear in Australia, and most of the insects will not feed indiscriminately on all species. Experiments had thus to be carried out to ascertain which insects will attack each of the more important species of pear. Again, the climatic conditions of different parts of the prickly-pear area vary considerably, so that it has been necessary to collect insects from various regions in America. The liberation of large numbers of certain species of insects is now proceeding. Naturally it will take a long time for them to establish themselves and multiply in sufficient numbers to cause any marked destruction of the pear over any considerable areas. Whilst, therefore, the process must be slow, the results recently obtained indicate that there is every reason to believe that ultimate success will be achieved.

A beginning has already been made in the investigation of fungous and bacterial diseases which attack the pear, and which, in the opinion of some authorities, are likely to be equally as effective as insects. In particular, investigations are being carried out in America and the Bermudas regarding certain diseases which cause great havoc to prickly pear in the latter country.

It is said that the pear has been spreading during recent years at the rate of 1,000,000 acres annually. Even if the investigations result in doing no more than preventing the spread, taking as low a value as 5s. an acre, the annual value of the work would be £250,000.

Another important investigation is that which the Council is carrying out on certain plant diseases in co-operation with the Waite Agricultural Research Institute, South Australia. An insect-proof glasshouse has been erected for the purpose of carrying out research work on virus diseases, soil-borne fungous diseases, and possibly other diseases of plants. For the present, work is being concentrated on tomato wilt, a disease which originated near Melbourne in 1915, and which has

spread to all the tomato-growing States. In certain years it has been very destructive over large areas, and in some localities has been so severe that whole plantations have been destroyed. The first object of the investigation is to ascertain the precise nature of the disease, and the means by which it is transmitted. Concurrently the investigation of other plant diseases will be undertaken at the Waite Institute, and efforts will be concentrated on some other disease as soon as the intensive work on tomato wilt reaches a stage to justify transfer of concentration.

In Queensland, investigations are being carried out on two diseases of bananas, viz., "bunchy-top" and "squirter." The major part of the investigations on "bunchy-top," a disease which has practically wiped out the banana plantations in certain areas, has been completed, its cause and the means by which it is spread have been discovered, and recommendations for control have been made to the State authorities. During recent years, a disease known as "squirter" has become prevalent, and occurs particularly in fruit sent from Queensland to the southern markets. It consists of a softening and darkening of the centre of the fruit, and an eventual conversion into a mushy liquid. The investigations so far carried out indicate that the disease is due to certain conditions of storage and transport, and that it is related to similar troubles which arise in other fruit, such as "brown-heart" in apples.

In co-operation with the Development and Migration Commission and the British-Australasian Tobacco Company, the Council is undertaking a comprehensive investigation with a view to ascertaining whether tobacco can be grown in Australia equal in quality to that now grown in North America. The investigation will cover the whole question of the improvement in quality, and the economic production of various types and grades of tobacco, and will include problems of the soil, plant growth, climatic conditions, and economics. Arrangements for proceeding with the work were made at the first meeting of the Standing Committee on Agriculture last May.

The New South Wales Department of Agriculture has been asked to allow Dr. G. P. Darnell-Smith to prepare a report on the general position, and to indicate the lines on which he considers future work should be developed. A chemical examination of the differences between Australian and Virginian leaf will be carried out under the control of Professor J. Kenner, Department of Organic Chemistry, Sydney University.

Investigations are being carried out on diseases of peas and hops, which cause great damage in Tasmania. As a result of the work already done, it has been possible to give definite advice to growers. Further work of a fundamental nature is in progress at Melbourne University by Dr. Ethel MacLennan.

The Council is also formulating plans for a comprehensive campaign of investigation of tropical agricultural problems. The British Empire Marketing Board has offered to contribute £25,000 towards the capital cost, and £5,000 per annum towards the annual maintenance on a £1 for £1 basis with the Commonwealth for the establishment of a Tropical Agricultural Research Institute in Queensland. The creation of such an Institute is obviously of immense importance in connexion with the development of the tropical parts of Australia. The Council

is actively engaged in preparing a definite scheme for the work and organization of the Institute, its capital cost, annual expenditure, equipment, and staff.

The Council also has under consideration plans for creating a special section to deal with problems in economic botany.

9. Investigations on Irrigation Settlement Problems.

The Council has been impressed with the importance of investigating the many problems which affect fruit-growers in the Murray River settlements, extending from the Murrumbidgee irrigation area in the east to Renmark and other places in the west. It has approached the whole matter from a geographical stand-point, without reference to State boundaries, and has now completed plans for steady developments in several centres. The main investigations into citriculture and its problems will be centred at Griffith, in the Murrumbidgee irrigation area, New South Wales. A Research Station was established there some years ago, and is now owned and financed jointly by the Council and the Water Conservation and Irrigation Commission of New South Wales. The latter body is contributing £1,500 per annum towards the expenses of the Station, and is supplying all water free of cost. The present area of the Station is about 80 acres, but reservations of 200 acres for research into rice-growing, and of about 20 acres for investigations into deciduous fruit tree problems are under consideration. Investigations are being carried out on cultural and manuring problems, bud selection, and citrus stock. As the first trees were planted out only in 1924, it is too soon to expect any definite results. It is inevitable that some years must elapse before any very definite conclusions can be reached. Great interest is being taken in the investigations by the growers in the irrigation area, and particularly in the tile drainage experiments, from which it already appears that "salt areas" can be eliminated by proper methods of irrigation and drainage. Investigations of this nature are of special importance in connexion with the Government's marketing policy, since it is essential for Australia to be able to place the highest grade standard fruit on foreign markets if we are to compete successfully with other countries.

The progress of rice-growing in the Murrumbidgee areas is very striking. This year 5,000 acres are under crop, and where farmers have paid careful attention to the advice given them the yields have been very satisfactory. The rice consumption in Australia is limited, and probably 20,000 acres will suffice to produce it. There appears, however, to be an enormous market available in Japan, which at present imports large quantities from California. The development of this industry will undoubtedly bring all sorts of problems to the grower, and the Council for Scientific and Industrial Research and the Irrigation Commission hope to be ready with a research organization to tackle such problems before they reach serious magnitude.

For work in viticulture, the Council has taken complete control of the Research Station at Merbein, near Mildura, which was formerly under the control of the Mildura Vineyards Protection Board, but which is now wholly financed by the Commonwealth. Extensive additions to the work of the Station are being made. The area of the Station is 86 acres, most of it being irrigable. This land was provided by the Victorian State Rivers and Water Supply Commission, which is

closely associated with all work carried on. Lengthy investigations into manurial and processing problems are being carried out, and already considerable success has been achieved. It has been estimated that the introduction of the "cold-dip" process for the drying of sultanas, which was introduced largely as the result of work at the Merbein Station, represented a gain in quality of product which was worth about £30,000 to the industry during last season alone.

Probably the most fundamental section of the work now in hand is the soil survey, which is under the direction of Professor J. A. Prescott, of the Waite Institute, University of Adelaide. The analytical work will be carried out in Adelaide and at Griffith by uniform methods. Attempts will be made to correlate the physical, chemical, and bacteriological constitution of the soils, and the original natural vegetation carried by them, with the results obtained by growers in their vineyards, citrus groves, and orchards. Though it will be some time before results will be yielded by this work, the value of it in years to come, as fresh lands are made available for settlement, should be very great indeed.

10. Investigations on Entomological Problems.

In view of the great importance of investigating the various insect pests which levy so large a toll on our agricultural, horticultural, and pastoral industries, the Council is preparing plans for the creation of a special Entomological Section. At present the principal problems under investigation are the grass-grub, the buffalo-fly pest, and dried fruit pests.

A serious state of affairs has arisen in Tasmania through the depredations to pasture lands caused by a species of underground grass grub. As a result of the damage done to the roots of the grass, pastures are rapidly eaten out in the early spring, and very little feed is left for the summer months. In many localities the pest has entirely upset the ordinary farming rotation systems. A considerable amount of work has already been done by Mr. G. F. Hill, an officer of the Council, in ascertaining the life-history of the grub, and on methods for its control. During the forthcoming season, field experiments will be carried out with a power-spray outfit.

The buffalo-fly is one of the most serious menaces to the cattle industry in the Northern Territory, and in the northern parts of Western Australia. The injury to the cattle is not due to the transmission of any disease, as in the case of the cattle-tick which causes red-water, but is caused by the incessant annoyance, irritation, and loss of blood owing to the flies clustering around the base of the horns and other parts of the bodies, and to abrasions caused by the animals in their efforts to dislodge the flies. It is believed that the pest was introduced into Australia from Timor, from which country the cattle-tick was also introduced. The cattle-tick has already spread through Queensland, and has only been prevented from further spread southwards by the action of the New South Wales Government in maintaining a buffer area on the State border. It has already caused enormous financial loss to the Australian cattle industry, and if the buffalo-fly extends similarly, it is believed by many authorities that it will prove an even worse pest than the cattle-tick.

In co-operation with the Western Australian Department of Agriculture, the Council arranged for an investigator, Mr. D. Murnane, B.V.Sc.,

to make observations as to the spread and prevalence of the pest, initially working from Wyndham, Western Australia, as a centre, and then proceeding via Darwin, through the Gulf Coast country, to Queensland.

Information regarding the prevalence of the pest, methods of control, and the likelihood of finding parasites which destroy the fly, has now been obtained by the Council from entomological authorities in the Dutch East Indies, the Philippines, and the Hawaiian Islands. The problem of control is one of very great difficulty, and the Council is now obtaining authoritative advice as to the most economical and effective lines along which further investigation should be conducted.

The problem of insect pests which infest our dried fruits, and which have threatened great damage to the industry, is being investigated by the Council in co-operation with the Empire Marketing Board. Dr. J. G. Myers, of the Imperial Bureau of Entomology, has carried out investigations in Victoria and South Australia, and arrangements were made for him to obtain definite information regarding shipboard conditions by inspecting consignments of fruit sent by the ship on which he is returning to England. From the preliminary report which Dr. Myers has furnished, it appears that there is every prospect of attaining almost complete control of the pest without the necessity of any elaborate methods of fumigation. As a result of action taken by the Council's Officer-in-charge of the viticultural work at Merbein, and by officers of the Department of Markets, great improvements have already been effected in the conditions in the packing sheds. Concrete floors, care in the disposal of waste fruit, and general vigilance have resulted in a marked diminution in the degree of infestation. Until Dr. Myers has studied conditions on board ship, and has examined the consignments after arrival in England, it is impracticable to give a final decision, but it is probable that the solution of the problem will be found along the lines followed this season in many of the packing sheds.

The Council is co-operating with the New South Wales Department of Agriculture in investigations on the sheep blow-fly problem, and has made the services of two officers available, one an entomologist, the other a veterinary officer, to assist in the work which that Department is conducting at its experimental station at Nyngan.

11. Investigations on Animal Pests and Diseases.

The Council was impressed with the importance of undertaking further work in Australia on the diseases and pests of animals of economic value. Comprehensive figures showing the total annual loss entailed through these pests and diseases are not available, but there is no doubt that it runs into some millions of pounds sterling. It is estimated that, in a bad year, the loss from the sheep blow-fly pest alone is as much as £4,000,000.

Investigations on many of the most serious pests and diseases are already being carried out at one or other of the Veterinary Research Institutes in the Commonwealth. Further progress in their control and eradication can generally be made only as a result of fundamental scientific investigation as to the nature of the diseases, their causes and the agencies by which they are spread. The Council, therefore, convened a Conference of leading veterinary pathologists in order to

obtain advice as to what action could best be taken in the matter. As a result it was decided to offer financial assistance to the Veterinary Research Institutes in order to enable them to employ competent workers to carry out investigations on a number of problems which cause great loss to our pastoral industries. This has been done, and various investigations are now in progress. For example, work is being carried out at the Glenfield Animal Research Institute, New South Wales on (*a*) paralysis in pigs, a disease which occurs especially in young pigs being topped off for the bacon factory, and which is a matter of great concern to the dairying industry; (*b*) toxaemic plethora, which causes high mortality in the best lambs, and of which the cause is quite unknown; and (*c*) sterility in cows, which is also of very serious concern to dairy farmers. At the Sydney University Veterinary Department work is being carried out on braxy disease in sheep, a disease which occurs under different names in several of the States, and on caseous lymphadenitis in sheep, which is prevalent in Australia, and which is becoming of serious importance in connexion with the export of frozen sheep. Investigations on parasitological problems are also being carried out by Mr. I. Clunies Ross, B.V.Sc. At the Melbourne University Veterinary Research Institute investigations are in progress on bovine pleuro-pneumonia and tuberculosis in cattle.

Kimberley horse disease is a problem of major importance which the Council is investigating in co-operation with the Western Australian Department of Agriculture. This disease interferes seriously with the proposed settlement in the northern parts of Western Australia, and appears to be identical with "Walk-about disease" in the Northern Territory and "Birdsville disease" in Queensland. It is stated that in the West Kimberley district of Western Australia 30 per cent. of the horses die from the disease every year. A veterinary officer and a botanist have been sent to the Kimberley district to carry out a scheme of work which had been drawn up with a view to ascertaining the precise nature of the disease. Whether it is a parasitic disease or not is still obscure. One theory for which a good deal of evidence had been put forward is that it is due to a certain poisonous plant which is eaten by the horses, and which is particularly virulent at the stage of early growth after rains. Though the Council's advisers are sceptical about the adequacy of the evidence in support of this theory, and consider that other possibilities have been quite insufficiently tested, it seems desirable to make a thorough study of such edible plants as may be exerting a poisonous effect. It is hoped that the results of the work on the pathological and botanical sides will clear up the problem of the nature of the disease, and so open the way to the devising of means for its prevention, or, at any rate, for its treatment.

In certain parts of the Commonwealth poisonous plants are sometimes credited with causing heavy losses of stock. It is difficult to estimate the extent of the damage done, since there is often wide diversity of opinion regarding the precise causes of sudden mortality in flocks and herds. The Council has arranged, in co-operation with the New South Wales Department of Agriculture and the University of Sydney, for a thorough inquiry, which will probably extend over several years, into the principal poison plants of the Commonwealth. There are three sections to the work. On the organic chemical side the main part of the work will be carried out under the control of

Professor J. Kenner at the University of Sydney by chemists on the staff of the Council. There will also be collaboration in this part of the work with the chemistry section of the Sydney Technological Museum. On the veterinary side, the experimental work will be conducted at the New South Wales Government's Veterinary Research Institute at Glenfield by Dr. Seddon, while the pharmacological section will be carried out at Professor H. G. Chapman's Department, University of Sydney.

From a combination of these three lines of investigation, it should be possible to obtain a great deal of evidence upon which to base preventive or remedial measures of value to pastoralists and others. It is possible, too, that products will be isolated which will be of service in pharmacology, since little has been done yet in the direction of determining the medicinal values of essential principles contained in Australian plants.

12. Stock Nutrition Investigations.

Arrangements have been made by the Council for an extensive and fundamental investigation into problems associated with the nutrition of stock in Australia. The work is being carried out by the Council in co-operation with the University of Adelaide and the Waite Agricultural Research Institute. From many quarters the Council has received evidence of the need for a carefully-planned systematic investigation into such questions as the composition of pastures from the points of view of their protein, mineral, and vitamin contents; the regeneration of depleted natural pastures; and the relations between growth of stock, nature of pasture, and geological type of country. At first the applied work will be limited mainly to sheep, considered both as meat and wool producers. In planning this work the Council is looking very far ahead. The work is far from being spectacular, and cannot be expected to show major results for some years, but of the imperative need for such a development in Australia there can be no two opinions.

The investigations have been planned in two main divisions. In the first place, arrangements have been made for a fundamental investigation of the nutrition of animals to be carried out under the control of Professor T. B. Robertson, University of Adelaide. The whole of his technique, as well as his trained assistants, has been placed at the disposal of the Council, which is erecting a laboratory at Adelaide for the purpose of carrying out the work. At first investigations will have the primary object of ascertaining the exact nature of certain deficiencies in leaf proteins of those fodder plants upon which Australian sheep chiefly depend in times of drought. Afterwards the investigations will be extended to other plants, especially to those which make their appearance after rain in the arid districts, and finally to the pasture plants of the districts which have a more abundant rainfall. Investigations with laboratory animals will also be carried out in order to determine the effect of excess magnesium or potash upon the mineral requirements of the animal in other directions, and the information thus obtained will be of value in enabling pastoralists to correct known excesses of this nature by the use of licks or by the addition of minerals to stock waters.

Secondly, this fundamental work will be linked up with field investigations on sheep at the Waite Institute. At the present time

the problem of mineral deficiencies of pastures is exercising the minds of agricultural authorities throughout the Empire. The Empire Marketing Board has made funds available on a contributory basis for carrying out research on this problem in Australia. This offer was originally made to Professor A. E. V. Richardson, Director of the Waite Institute, when he was in England last year. The offer has now been transferred to, and accepted by, the Council. The general object of the work is to determine the role of mineral nutrients on the growth, development, and nutrition of stock. Special attention will at first be devoted to the effect of deficiencies of phosphorus and calcium on pastures typical of the large areas of territory which are notably deficient in these constituents. With Professor J A. Prescott to advise on soil problems and Professor T. G. B. Osborn on plant problems, and especially on problems of regeneration of fodder grasses and plants which he has been studying for some years on a station at Koonamore, South Australia, an effective organization has been created to accumulate knowledge on these very important problems of nutrition.

During the 1926-27 drought, which existed over large areas of Queensland, sheep and cattle were fed with many different varieties of emergency fodders. Representations were made by various authorities in Queensland, such as the United Graziers Association and the Longreach Chamber of Commerce, that much valuable information would be obtained if some suitably qualified person were appointed to visit the various districts and collect information that would be available as to the effects of these different fodders, &c. Arrangements were accordingly made by the Council in January, 1927, for an officer to make these inquiries. The work is now being carried out, and will be completed in the course of a month or two.

13. Forest Products Investigations.

Prior to the creation of the Council very satisfactory results had been obtained from the investigations on paper pulp initiated by the former Institute of Science and Industry, and carried out by Mr. L. R. Benjamin. An investigation on the pulping of eucalypt woods by the sulphite process was first taken up in 1924, following the successful application of the soda process in a modified form to the pulping of eucalypts. As a result, it appeared that there was every probability of manufacturing sulphite pulp sufficiently cheaply to allow of its use in the manufacture of newsprint, of which over 100,000 tons per annum are imported into Australia. The matter was taken up by certain commercial interests, which carried out a large scale test in Europe, for which purpose 100 tons of stringybark wood from Tasmania were used. The results obtained in the laboratory with a few pounds of wood were thus repeated on a 100-ton lot, and the agreement in results was satisfactory. Financial interests have now decided to expend up to £50,000 to try out the practicability of manufacturing newsprint on a 1 ton per day plant, and it is stated that if the results are satisfactory the establishment of the newsprint and sulphite cellulose industry, involving the expenditure of from £1,500,000 to £2,000,000 in the course of the next five or six years, is assured.

The Council has recently concentrated its work in this sphere on the production of a satisfactory mechanical pulp for use, together with chemical pulp, in the production of newsprint. Definite conclusions

have now been reached as a result of this work, and it is believed that they will assist materially in the establishment of the newsprint and sulphite cellulose industries. Four outstanding factors have been established on the laboratory scale. The first is that approximately 30 per cent. of groundwood or mechanical pulp from certain immature eucalypts can be used with sulphite pulp from similar woods. Secondly, adjustment of mechanical conditions in sulphite cooking have resulted in considerable reduction of cooking time (from ten to six hours—a saving of four hours), with a pronounced increase in yield and improvement in quality of pulp for newsprint purposes. The third important point is that bleaching of sulphite pulp is unnecessary for newsprint, and the fourth is that the combined result of the new data which has been obtained indicates a reduction of from £2 to £3 per ton in the cost of production of newsprint.

During the sulphite pulp investigations the purity of the various products was carefully studied, and results were obtained indicating the practicability of producing a very high grade cellulose suitable for the manufacture of artificial silk. This aspect of the sulphite pulp investigation is being followed up actively by the Council, and arrangements are being made to send samples of the pulp to England to try out its suitability for the manufacture of artificial silk.

Very promising results have also been obtained from the Council's investigations on *Pinus insignis,* an imported pine planted largely throughout Australia. It has a considerable advantage over other woods in its remarkable rate of growth. The results show that the pulp from *Pinus insignis* is eminently suitable for use in the manufacture of the strong brown wrapping paper used for paper bags, &c., commonly known as kraft paper. Large quantities of *Pinus insignis* are available, especially in the south-eastern parts of South Australia, and there is every reason to believe that all the kraft pulp required in Australia can be produced in this country in the next ten or twelve years, and that the quality will be equal to that of the paper now imported. The Council, in co-operation with the Development and Migration Commission, is arranging for semi-large scale tests to be carried out in the belief that they will lead to commercial exploitation on a large scale.

It is common knowledge that the position of Australia with respect to materials for tanning is not satisfactory, and that although this is the home of the wattle, large quantities of bark are now imported from South Africa. A comprehensive survey of Australian tannin resources has now been completed by Mr. D. Coghill, an officer of the Council. Broadly speaking, the results show that, in addition to the well-known wattles, Australia is comparatively well off for tanstuffs. This is particularly the case in Western Australia. Most of the tannins are found to occur in various members of the genus *Eucalyptus.* The tropical areas of Australia are also rich in high tannin content mangroves. The results so far obtained indicate that abundant supplies of various classes of tanning materials are available, and that some of these could most likely be worked up to form suitable tannin extracts. Now that the necessary preliminary work has been completed the Council is energetically attacking the problem of the commercial production of tannins in the form of extracts. A small semi-commercial scale tannin extract plant is being erected in the grounds of the University of Western Australia, and the investigation of the higher grade and more abundantly occurring tanning materials from

the point of view of tannin extracts is to be initiated at once. This work is being undertaken by the Council in co-operation with the Western Australian Forestry Department and the University of Western Australia. It is under the general control of a committee consisting of Mr. S. L. Kessell, Conservator of Forests, Western Australia, and Professors Wilsmore and Whitfield, of the University of Western Australia.

The Council has received a large number of requests to carry out investigations on various forest products problems and for the establishment of a forest products laboratory in Australia. It has been decided to obtain the advice of a highly qualified authority on the whole question, and at the request of the Commonwealth Government the Government of India has agreed to make available the services of Mr. A. J. Gibson, Conservator of Forests, Lahore, to visit Australia for a period of about four months, and to furnish a report and to advise on the whole matter. Mr. Gibson will arrive in Australia towards the end of July.

14. Investigations on Preservation and Transport of Foodstuffs.

The whole question of undertaking systematic investigations on problems connected with the preservation, storage, and transport of perishable food products has been carefully considered by the Council. The matter is obviously one of great importance in connexion with the export of foodstuffs from Australia and with the problem of finding markets. The Low Temperature Research Station at Cambridge has already carried out a considerable amount of fundamental work in connexion with these problems, and was, in fact, responsible for the solution of the problem of brown-heart in apples, a disease which formerly resulted in a loss to Australia of as much as £250,000 in one year.

As regards meat, probably the most important problem is that relating to the freezing and chilling of beef. Owing to the time taken by the voyage from Australia to England, beef for export has to be frozen, and when thawed frozen beef exudes an objectionable drip. The result is that the price obtained for Australian beef on the London market generally compares unfavorably with that of chilled Argentine beef. Investigations on this matter have been carried out by a committee of the Australian National Research Council, subsidized by a grant from the funds of the Council for Scientific and Industrial Research, and helped also by various facilities made available by the Victorian Department of Agriculture and by the Melbourne University. Results obtained on a small scale indicate that if beef can be frozen sufficiently rapidly its properties on thawing are very considerably improved as compared with beef frozen in the usual way. These investigations are being continued, and are being conducted specially with a view to studying the effect of the age of the beef, the variety of the beef, and other conditions of the beast prior to slaughter.

As regards fruit, though the mechanical production of cold has now reached a high state of efficiency, little accurate information is yet available concerning many important matters connected with the application of cold. A great deal of experimental work still remains to be done in regard to such matters as atmospheric conditions, the circulation of air and ventilation, methods of packing and storage, &c. The difficulties experienced in the export of citrus fruits from Australia are well known.

Other problems which require investigation relate to the development of means whereby tropical fruits can be successfully stored and transported long distances. Any satisfactory investigation of the problems relating to the preservation and transport of fruit would necessitate the co-operation, not only of the State Agricultural Departments, but also of the ship-owners and the authorities in England, since it is necessary that the work should cover all factors from the orchard to the consumer.

The Council accordingly arranged for Dr. F. Kidd, an officer of the British Food Investigation Board, to visit Australia in order to carry out a survey of the local problems, of the investigations already in progress, of the facilities available, &c. Dr. Kidd is now in Australia, and will furnish his report in about August next. It is expected that he will indicate a programme of research to be undertaken by the Council in co-operation with other organizations. He is accompanied by Dr. W. J. Young, whose services have been made available to the Council by arrangement with the University of Melbourne. The Council regards cold storage research as one of its major investigations, and as soon as Dr. Kidd's report has been received and considered, it proposes to proceed actively with the organization of the investigations.

15. Investigations on Fuel Problems.

In view of the serious national problem which has arisen as a result of Australia's dependence on other countries for the supply of her necessary liquid fuels, the Council has given a considerable amount of attention to the attitude it should adopt towards liquid fuel research, and in this connexion the question of the low temperature distillation of coal and shale is of importance. It has been decided that in view of the high cost of the complicated plant that would be necessary, of the existence of such a plant at the British Fuel Research Station, Greenwich, and of the enormous amount of work which is being carried out on these problems in other countries, the Council would not be justified in undertaking experimental work for the present. Two Australian post-graduate research students have, however, been sent to the Greenwich Station, and steps have been taken to ensure that the Council will be kept fully informed of all developments.

The Council has received many requests for assistance from various interests engaged in the oil shale industry in Australia. At the present time that industry is not generally being run with commercial success, and the requests have generally been for scientific assistance in the development of suitable retorts. The Council is co-operating with the Development and Migration Commission in an inquiry to ascertain what sections of the shale oil industry are chiefly responsible for its economic failure. It has been decided provisionally that if, as a result of this inquiry, it seems probable that the industry can be made to prosper by scientific investigation of certain aspects of it, the Council will make inquiries, and will give advice regarding the lines to be followed in such investigation.

Careful consideration has also been given by the Council to possible lines of research that could appropriately be undertaken in regard to power alcohol. Broadly, it is considered that the problem of fermentation alcohol is mainly of an economic nature, and that there

is little room for improvement of present processes by scientific investigation. As regards synthetic alcohol, it is felt that, as any investigation would involve costly apparatus, and as a great deal of work is being carried out in other countries, it is not appropriate for the Council to initiate researches at the present time. As regards the production of power alcohol from cellulose, however, investigations are being carried out under the direction of Professor N. T. M. Wilsmore, University of Western Australia, on the hydrolysis and fermentation of the commoner Australian hardwoods.

16. Miscellaneous.

In November, 1926, a conference was convened by the Council to advise on certain proposals which had been made for establishing a Radio Research Board in Australia. As a result, it was decided that the establishment of such a Board would be of advantage to all radio interests in Australia; that the primary function of the Board should be to originate, facilitate, and co-ordinate radio research investigations; and that the Board should direct its attention to (*a*) co-operation with the British Radio Research Board and with the International Radio Research Board, (*b*) consideration of scientific problems related to broadcasting in Australia, and (*c*) the improvement of equipment and other facilities available in Australia for electrical measurements at radio frequencies. The Board has now been established under the chairmanship of Professor J. P. Madsen, University of Sydney, and is carrying out its work in close co-operation with the Postmaster-General's Department and with the Department of Defence.

As a result of another conference convened by the Council, a committee has been established, also under the chairmanship of Professor J. P. Madsen, for the purpose of taking up the whole question of the maintenance and control in Australia of legal standards for weights and measures. This action has been taken partly for the purpose of giving greater effect to the valuable work of the Australian Commonwealth Engineering Standards Association and of providing for the sound development of technical and industrial work in Australia. It was felt that it would be premature to establish an Australian National Physical Laboratory at the present juncture, but on the other hand, it was agreed that the whole question of legal standards for the Commonwealth is one of urgency, and that valuable work could be done by utilizing existing institutions, such as the State Observatories and Universities and the Defence Department Research Laboratories.

A considerable amount of valuable work was carried out under the former Institute of Science and Industry on the utilization of Australian clays for the manufacture of higher grades of white china and earthenware. The present Australian market for whiteware is worth about £1,000,000 per annum, and the Council intends to proceed with the investigations. As a preliminary step, it has sent its investigator, Mr. R. C. Callister, to England for a special course of training at the Ceramic School at Stoke-on-Trent.

The Council has also given attention to a large number of other matters, and has acted as advisor to the Commonwealth Government on many subjects connected directly and indirectly with scientific work. It has, for example, furnished advice to the Government on the whole position of astronomical work in Australia. It has taken an active

part in connexion with the proposals made by the Interstate Geological Conferences for the establishment of a Commonwealth Geological Survey. It is inquiring fully into the whole question of geophysical methods of prospecting. It is carrying out investigations on mineragraphy with a view to the development of more efficient treatment processes for ores of base metals. It is carrying out investigations with a view to developing methods for the manufacture of artificial building stone composed of granite chippings and cement. It is revising and publishing a catalogue of scientific periodicals in Australian libraries, in order to facilitate the work of scientific investigators in the Commonwealth. In addition, it regularly supplies information on a great variety of subjects in reply to inquiries received from the public regarding scientific and technical matters, especially concerning new processes, manufacturing difficulties, and the utilization of new raw materials or substitutes therefor. The number of inquiries received shows that the Council has come to fill a place in the needs of the community.

The Commonwealth and Agricultural Research.

By Professor A. E. V. Richardson, M.A., D.Sc., Director, Waite Agricultural Research Institute, South Australia.

In 1926, Professor Richardson visited Great Britain, Denmark, Sweden, the United States of America, Japan, Java, South Africa, and Canada to inquire into the organization of agricultural research in those countries. In accordance with an Honorary Commission granted to him by His Excellency the Governor-General of the Commonwealth, Professor Richardson has furnished a report on "Agricultural Research in Other Lands." In that report he outlines the systems of agricultural research and education in the countries he visited, and he emphasizes the importance of agricultural research rather than of agricultural education, since other countries have found by experience that investigation of the principles underlying agricultural practice must be made before effective and sound teaching in agriculture could be developed. In the concluding part of his report, which is printed below, he deals with the functions of the Commonwealth in relation to agricultural research.—ED.

1. Value of Agricultural Research.

It is generally recognized elsewhere that the modern State, and particularly an agricultural State, must cultivate agricultural research and education if it is to become efficient, and survive in world competition with its agricultural products.

Research in agriculture is an insurance against the future. Without it farming practice will stand still, and the teaching of agriculture will have little meaning. Research in agriculture leads ultimately to more efficient production, higher economic levels, better social relations

in rural communities, and increased production from the land. Several illustrations, among many that might be quoted, may be given to illustrate the value of research in increased production. Marquis wheat, produced by Dr. Saunders, of the Dominion Experiment Farm of Canada, has practically supplanted all other varieties of wheat in the spring wheat region of Canada and the United States. It is estimated that its value in this area has led to an increased production worth several millions sterling per annum. William Farrer, Australia's pioneer wheat-breeder, whose monument can be seen in nearly every ripening wheat-field in Victoria and New South Wales, has added millions of bushels to Australia's wheat harvests. In South Africa, the scientific work of Sir Arnold Theiler on stock diseases has resulted in the saving of millions of sheep and cattle each year. The discovery of superphosphate by Liebig and Lawes has benefited Australian agriculture by at least £5,000,000 per annum.

Research increases production by placing the art of agriculture on a sound scientific basis, and it affords a sure means of ultimately controlling the diseases of our crops and stock, which at present exact such heavy annual toll.

2. Two Methods Available for Increasing Agricultural Production.

There are two methods available for increasing the agricultural output of a country, viz., (*a*) favorable legislation; and (*b*) agricultural research and education.

A bold immigration policy, the building of developmental railways, the improvement of roads, the conservation of water supplies, the extension of irrigation enterprises, the adoption of a liberal system of land settlement, the provision of favorable and secure tenure for pastoral settlement, the opening up of new markets abroad, the improvement of overseas transport, the development of minor industries, the provision of credit facilities—all these will aid agriculture, bring new areas under cultivation, and develop this country. They are all material aids to settlement, and to profitable agricultural and pastoral production.

The output of the State may be increased by all these methods, and by bounties and other artificial aids. But to secure a genuine and permanent increase in the output from the land, we need to improve the farming methods of the country, and to apply the teachings of science to every branch of primary production. That is the clear lesson of experience in all the great agricultural countries of the world.

We can make great progress in agricultural and pastoral production in Australia. We could certainly increase the wheat yield by at least 33⅓ per cent., and greatly increase the area under crop. The pastoral production of settled areas could undoubtedly be greatly increased by the application of more rational methods of treatment of our pastures. The output from dairying and irrigation could be greatly augmented by the adoption of improved practices. But to do this requires greater efficiency on the part of the man on the land, more complete knowledge of underlying principles, and greater perfection of technical processes. The degree to which we can progress towards intensified agriculture very largely depends on the personal efficiency of the average farmer, and the extent to which that efficiency can be increased. The establishment of a comprehensive system of agricultural research and education must form the basis of any

scheme for agricultural development and advancement. The farmers of the future, i.e., the youths of to-day, must have facilities and opportunity to acquire a sound training in agricultural science along with training that will make for good citizenship. The farmers of to-day must also be provided for by a system of extension work, such as was outlined in my report on Agricultural Education and Development in America. But underlying this instructional and extension work by the Department of Agriculture, the Agricultural Colleges, and the Universities, there must be a sound system of investigational and research work in agriculture, to elucidate the facts and the principles which will form the basis for all future developments.

3. Agricultural Research may be a Slow Process.

Agricultural research involves the patient and painstaking examination of agricultural problems, and its processes are necessarily slow. The rate of progress in agriculture must be slow if compared with the rate of development in other industries. Within the lifetime of individuals, there can be no such improvements in agriculture as the perfecting of the internal combustion engine has made possible in transport. Great as are the achievements, and still greater the possibilities, of agricultural research, there are limitations to the effect of science on agriculture which do not hold for other industries. In agriculture, we are dealing with plants and animals, and when dealing with living organisms we cannot speed up the processes of growth. As Sir Daniel Hall says, "It still takes the wheat plant six or nine months to develop, and cows bring forth their calves neither more quickly nor more numerously than they did for Abraham."

These limitations lie in the nature of things, and though we can count up the immense advances that agriculture owes to the application of knowledge, we must not hope for revolutionary changes such as have been witnessed in flying or wireless. The rewards in agriculture are not commensurate with those obtainable in industry or commerce, and so men are being drawn away to the cities, and capital is being diverted from the farms.

This movement is one common to all civilized countries, and its sources are social as well as economic. Perhaps this may be in part arrested by taking advantage of science, machinery, and organization, and intensifying agricultural production so that the industry will again become capable of competing with other industries for men and capital.

4. Agricultural Research a Function of the Commonwealth and State.

In farming there are no great business corporations. The whole of the farmers of a State benefit by a new discovery, by an improved variety, or by a new control of a serious disease. Research profoundly affects the development of agriculture. If the latter were merely the concern of the farmers, they might be left to provide it for themselves, but while they may share the first advantages of such development, they can realize no advantages that are not shared by the whole community. The development of agriculture is, therefore, a matter of vital public concern.

Agriculture is the basis of national wealth, and in all countries the public revenues are the main source of funds for agricultural research. Agriculture is enormously productive, and money expended on its

development will give a handsome return. Every bushel added to Australia's wheat yield means an addition of £2,500,000 per annum. Every insect and fungoid pest that can be brought under control brings great wealth to the community. Every contribution to our knowledge of stock management is of great public benefit.

The main difference between Australia and other countries is the national sentiment towards agriculture. Countries like the United States of America, Canada, South Africa, Denmark, and Japan not only believe that agriculture is the basis of the country's wealth, but they translate this belief into action, and express it in legislation. These nations think in terms of agriculture. This attitude finds practical expression in the liberality with which agricultural research is supported by national funds, and the readiness with which the peoples mentioned are prepared to map out policies for steady, continuous development over long periods.

We in Australia cannot be said to have developed a strong national sentiment towards agriculture and agricultural research, yet we cannot afford to remain oblivious to the developments that are taking place in other countries. Our farmers need as much aid as can be given them by modern science, and in view of the great economic importance of agriculture to the nation there is an obligation, both on the part of the Commonwealth and of each State, to support agricultural research to the fullest extent possible.

5. The Training of Specialists and Research Workers for Agriculture.

No matter from what angle the problem of agricultural education and research is viewed, it resolves itself ultimately into the problem of providing a sufficiency of trained teachers, agricultural specialists, investigators, and extension workers, and using them in an organized scheme of research, instruction, and extension. This is the clear and unmistakable lesson to be learned from the efforts of other countries.

We need trained investigators to establish the principles underlying the successful cultivation of crops and the feeding and management of live stock, and the principles underlying the control of diseases of crops and live stock. We need trained specialists in agriculture to foster the agricultural and live-stock industries of the State.

We need trained and tactful extension workers whose efforts will be continuously directed to the improvement of practices in local communities by getting into personal touch with those whose farms have hitherto given but mediocre yields.

The first and fundamental problem is to develop a scheme of training investigators, teachers, and specialists in agriculture. This can be done by encouraging and developing the work of the Faculties of Agriculture that have been established in the Universities. In the United States, under the Nelson amendment of the *Morril Act* 1907, each of the forty-eight Colleges of Agriculture receives an appropriation of £10,000 per annum from the Federal Government towards its maintenance. In South Africa, the Union Government contributes £15,000 per annum towards the maintenance of the two Faculties of Agriculture at the University of Stellenbosch and the Transvaal University. In Great Britain, the Imperial Government has provided £20,000 for capital and £53,000 for maintenance for the University Departments of Agriculture for 1926-27 alone. In Japan, the whole cost of the

Faculties of Agriculture is maintained by the Imperial Government. No University Department of Agriculture in any of the Australian States has equipment, personnel, and staff approaching those of similar institutions in Europe, South Africa, the United States of America, Canada, or Japan. In view of the precedents that have been established in other countries, it is suggested that the Federal Government should financially assist the University Schools of Agriculture to bring these institutions into line with modern requirements, and to provide adequate facilities for the training of research workers and agricultural specialists.

It may be contended that the encouragement of agricultural education is not a function of the Commonwealth. To that objection there is the policy followed by the United States, Canada, South Africa, Japan, and Great Britain, in which countries Federal or Imperial aid has been deliberately given to agricultural education in view of the great national importance of agriculture. Moreover, it would appear from clause 13 of the *Science and Industry Research Act* 1920-26 that the Council for Scientific and Industrial Research has been given the necessary powers to provide such assistance. Finally, on the broadest of all grounds, agricultural education is of vital importance to the Commonwealth, for history shows that no country can rise permanently above the condition of its agriculture. What the people of the country are to-day the people of the city will be to-morrow. In Germany, it has been established that the family that moves into the city dies out in five generations, and Carver, of Harvard University, has shown that there are practically no Americans who do not trace back to the country in three generations.

If Australia is to continue a white man's country, and permanently retain its high standards, our farmers must be of the highest type, because the city of to-morrow is built upon the farms of to-day, and a higher type of intelligence on the farms to-day means a higher type of civilization in the cities of the future. On these broad grounds and also because of the national importance of agriculture, the fostering of agricultural education so that rural people will be efficient, and the development of agriculture to the highest possible limit so that farming will be profitable, productive, and permanent, are obligations of the Commonwealth as well as of each of the States.

6. Agricultural Research in relation to the Council for Scientific and Industrial Research.

The Commonwealth Government has created by Act of Parliament the Council for Scientific and Industrial Research with power, *inter alia,* of initiating and carrying out scientific researches for the promotion of primary and secondary industries. As the primary industries are of such outstanding importance to the welfare of the Commonwealth, it may be expected that the major researches will be related to the primary industries, and ultimately to agricultural and pastoral production. Such a development would be but natural, and from what has happened in other countries, particularly in the United States, Canada, and South Africa, it may be expected that ultimately the Commonwealth must become associated, to an ever increasing extent, with research into agricultural and pastoral problems. Hitherto agricultural research and investigation in Australia has been a function of the

State Departments of Agriculture and of the University Faculties concerned. That there is a big field of work in agricultural research awaiting the Commonwealth is evident from the deliberations of the recent Agricultural Conference convened by the Council for Scientific and Industrial Research. This Conference, comprising the permanent Heads of every State Department of Agriculture and the Professors of Agriculture at the Universities, unanimously reported that, in view of the number and magnitude of the problems confronting the agricultural and live-stock industries of Australia, Commonwealth participation in agricultural research was desirable. The Conference indicated that, in this field, there were many problems which were of a national character, and required concentrated effort and highly specialized research for their solution, and that these problems were specially suited for investigation by the Commonwealth.

The research problems confronting the agricultural and live-stock industries may be classified broadly into three categories:—

1. Investigation of the principles underlying the practice of agriculture, and the rearing and feeding of stock.
2. The production of new varieties of plants or breeds of animals.
3. The investigation of the diseases of plants and animals with a view to control.

The problems of a more fundamental character, and which affect all States, or several States, are best undertaken by the Commonwealth. Big problems can only be handled by a big organization. Live-stock diseases and the numerous fungoid and insect pests which affect farm crops do not observe State boundaries, and the investigation of methods for control can best be undertaken by an organization of Commonwealth scope. Similarly the investigational work necessary to precede the establishment and development of new crop industries in the Commonwealth, and the introduction and investigation of the possibilities of new plants from other countries, can be better done by a Commonwealth than a State organization. There need be no overlapping of Commonwealth and State activity in the field of agricultural research if the Commonwealth restricts its efforts to the larger, more or less national and fundamental problems, and leaves the States to work on those of more or less local importance and interest and to the application of the principles discovered to the improvement of practice. For while it is true that research on fundamental and big national problems requires concentration of effort, team work, and highly specialized technique, it is equally true that for the application of knowledge decentralized effort gives the best results.

It is also desirable that Commonwealth activity in agricultural research should be carried out, so far as is possible, in co-operation with existing agricultural institutions, namely, the State Departments of Agriculture and the University Faculties of Agriculture and Research Institutes.

Co-operation between the United States Department of Agriculture and the State Colleges of Agriculture has been a marked feature in all agricultural research conducted in that country. The United States Department of Agriculture has devised a simple and effective plan of defining Federal and State activities in the shape of a "Memorandum of Understanding" under which each contracting party sets forth in

simple language the precise work which each would undertake in a co-operative project. This memorandum is not couched in legal language, but it places the responsibility for the general policy of the investigation on the Secretary of Agriculture in the one case, and the head of the Agricultural College or the State organization in the other. It leaves the details of carrying out the co-operative investigation to the men who are primarily concerned with the work.

7. Policy in Administration of Agricultural Research.

Countries vary in their policies for the administration of agricultural research. In the United States, a strong central Department of Agriculture has been created at Washington with twelve Scientific Bureaux for the administration of the regulatory measures, the carrying out of extension work in agriculture, and the conduct of research work. The staff of the Department includes some 15,000 officers. Much of the research work, however, is done at the Agricultural Experiment Stations, some 48 in number, which with two exceptions are an organic part of an Agricultural College or a University. Each of the 48 Experiment Stations receives an appropriation under the Hatch, Adams, and Purnell Acts of £18,000 per annum from the Federal Department of Agriculture. From State sources these funds are supplemented by an average of £36,000 per annum for each Station.

A marked contrast in administrative policy for agricultural research has been followed by the British Government. The Ministry of Agriculture does not, as a matter of policy, carry out research work in agriculture, but it is responsible to the Imperial Government for the general control of agricultural research in Great Britain. The field of this research was divided up into groups of related problems, and the Government, through the Ministry, allocated the problems, and the necessary funds for attacking them, to the various (some fifteen) Research Institutes and Universities throughout England, Scotland, and Wales.

In South Africa, agricultural research has been highly centralized since the advent of the Union, by the establishment of Scientific Divisions of the Union Department of Agriculture, and the absorption by the Union Government of the Provincial Department of Agriculture.

In Canada, both Dominion and Provincial Departments of Agriculture carry out research work, but there is the closest co-operation between Federal and Provincial authorities. The Dominion Department is concerned with problems of national character, whilst the Provincial Departments are concerned with investigations of a local character and the application of scientific knowledge through extension agencies.

In all these countries liberal appropriations for agricultural research are made by the central Government. In the United States the Federal Government provides the Department of Agriculture with an annual vote of £20,000,000 for road construction work in addition to about £8,000,000 for purposes of a purely agricultural nature. Of the latter amount probably 15 to 20 per cent. is devoted to research and investigational work.

The Canadian Government appropriates £1,200,000 per annum for the Dominion Department of Agriculture, and the South African Government £1,138,000 for the corresponding Union Department.

The expenditure by the Ministries of Agriculture of Great Britain and Ireland amounts to £3,800,000. Probably an average of 25 per cent. of these appropriations is devoted to research and investigational work.

Australia appears to be the only agricultural country where the national Government has not hitherto associated itself with the development of agricultural research. Through the establishment of the Council for Scientific and Industrial Research the machinery now exists for the development of agricultural research of a national character. To achieve results that would be comparable with those obtained in other countries, it would be necessary to provide this organization with liberal funds for the necessary trained men, equipment, and facilities for research. In other countries the public revenues are the main sources of funds for agricultural research, and the appropriation of such funds has been justified by the returns which sooner or later come through more efficient production.

The remarkable results which have been obtained in other countries by the application of science to agriculture will not be achieved in Australia until the same proportional investment of funds is made for research as other countries have made, nor without the same strong belief in the ultimate outcome of the investment.

Animal Nutrition Problems.

By Professor T. Brailsford Robertson, Ph.D., D.Sc., Officer-in-Charge of Council's Animal Nutrition Investigations.

Arrangements have been made by the Council for an extensive and fundamental investigation into problems associated with the nutrition of stock in Australia. The work is being carried out in co-operation with the University of Adelaide, and the Waite Agricultural Research Institute, South Australia. The investigations have been planned in two main divisions. Firstly, a fundamental investigation of the nutrition of animals is being undertaken by Professor T. B. Robertson, and for the purpose of this investigation a laboratory is being erected by the Council in the grounds of the University of Adelaide. Secondly, the fundamental work is being linked up with field investigations on sheep at the Waite Institute, and elsewhere. In this article, Professor Robertson describes the nature of the problems to be attacked, and the lines to be followed in the investigations.—Ed.

1. General Statement of the Problem.

The conditions of the pastoral industry in Australia are in many respects peculiar to this country. Over a very large proportion of the total pastoral area the climatic conditions are of the semi-arid type, and during a considerable and variable proportion of the year the fodder plants available for the nutrition of animals are very limited in

variety. Water is in general supplied by artificial means through dams or bores, and in the latter case may not represent surface drainage from the area upon which the sheep are fed.

The lack of variety of fodders inevitably compels the animal to depend upon the constituents present in a few species of plants for all its needs, with the exception of those minerals which may chance to be supplied in the water usually of an underground origin. If, then, there should chance to be any constituent which is essential to the well-being of the animal and low in quantity in the fodders which are accessible to it, the carrying capacity of the area upon which the animals are grazed must be absolutely determined by this limiting factor. In other words, if the sheep requires not less than a certain amount of this limiting constituent to maintain its well-being, then it must continue to eat, if possible, until it has procured this necessary amount of the limiting substance. The amount that the sheep will have to eat to satisfy this need will be determined by the scarcity of this limiting substance in the fodder.

In a mixed pasture containing an abundant variety of weeds and grasses, the animal can readily supplement the deficiencies in one pasture plant by partaking of another which supplements it in these particulars. In our semi-arid pastoral districts the sheep are for many months of the year deprived of opportunity to select their diet in such a way that the deficiencies in one fodder can be supplemented by superabundance in others.

In former years it was the custom of pastoralists who owned large holdings to assist the sheep by moving them from one pasture to another, preferably to a different type of country, so that the period of relative deprivation through the monotony of the fodder should be rectified on some other pasture. This plan of feeding has been carried out for many centuries in different parts of the world, and so long as it was possible, it was generally effective. The splitting up of the larger holdings in Australia into smaller allotments has made this procedure impossible, with the result that, during the past 30 years, the numbers of sheep in Australia have remained practically stationary, notwithstanding this subdivision and also the fact that water supplies, through boring operations and improved conservation, have become much more abundant than formerly.

It is clear that if the sheep industry in Australia is to be restored to its former level, or even maintained at its present level, some means must be found of supplementing the natural deficiencies in the pasture plants, other than that of shifting the sheep from pasture to pasture.

Judging from the experience gained with other animals, one would infer that the deficiencies most likely to occur in natural fodders would fall into one of two groups:—

(i) *Amino Acids,* which are the building stones out of which the tissue proteins of the animal are constructed. These elementary building stones of protein are synthesized by plant tissues, but, with one exception, are not capable of synthesis by animal tissues, with the result that, with this single exception, if any one of them be lacking in the food supply to the animal, the whole of the rest of the food becomes valueless so far as building up tissue is concerned. The amino acid requirements of the sheep may be expected to be similar to those of other animals since the tissue proteins of all animals resemble one another very closely in their

amino acid composition, with this exception, however, that since hair and wool are exceptionally rich in cystine, which is the only amino acid containing sulphur, the requirements of the sheep for this amino acid may possibly be considerably in excess of the requirements of other animals, and it may turn out eventually that cystine is one of the limiting factors in determining the production of wool. For the rest the amino acid requirements of the sheep may be inferred with a fair degree of confidence from the amino acid requirements of other animals.

(ii) *Mineral Salts.*—The mineral requirements of an animal are numerous and complex, and it cannot be said at the present moment that they are thoroughly understood in Australia, or anywhere else. We know that a great many mineral elements are essential, some of them —such as magnesium, iodine, fluorine, and possibly even zinc and copper—being required in exceptionally small amounts. Absence or deficiency of iodine results, as is well known, in disordered functioning of the thyroid gland, but absence or deficiency of other mineral elements may produce not less far-reaching effects, although frequently more difficult to recognize.

Not only, however, is it requisite to provide all of the mineral salts needed, but we know in many cases that it is essential to provide them in a proper proportion to one another. Excess of one mineral constituent may lead, in fact, to a virtual deficiency of another. Thus, it is known that excessive ingestion of potassium salts increases the requirement of animals for sodium, so that a diet which was formerly adequate in its sodium content becomes inadequate in its sodium content if excess of potash is added to it. There is strong reason to suspect that the same reciprocal relationship may hold between magnesium and calcium, and other pairs of mineral constituents in the diet. Not only in the case of the sheep, but in other animals as well, we at present lack adequate knowledge of these reciprocal relationships among the mineral constituents of the diet, but as most stock waters are rich in magnesium, and as the fodder plants in the semi-arid regions are frequently rich, both in magnesium and potash, it will be evident that we cannot infer the mineral requirements of the sheep in Australia until we know what exceptional mineral requirements may arise in consequence of these excesses.

2. General Objects of the Investigation.

The investigations will be undertaken with the primary object of ascertaining, so far as possible, the exact nature of the amino acid deficiencies in the leaf proteins in those fodder plants upon which Australian sheep chiefly depend in times of drought. Afterwards the investigation will be extended to other plants, especially to those which make their appearance after rain in the semi-arid districts; and finally to the pasture plants of the districts which have a more abundant rainfall.

Simultaneously it is proposed to investigate upon laboratory animals the effect of excess of magnesium or potash upon the mineral requirements of the animal in other directions. For example, having determined the normal mineral requirements upon a balanced mineral ration, the magnesium intake will be doubled, trebled, or quadrupled, and the mineral requirements re-ascertained; the information thus derived should enable us to correct known excesses of this nature by the provision of licks, or the addition of minerals to the stock waters.

3. Outline of the Investigations.

The investigations which it is proposed to undertake will fall into three groups, namely:—

(i) Investigations upon laboratory animals.
(ii) Field investigations upon sheep.
(iii) Chemical investigations.

(i) *Investigations upon Laboratory Animals.*—Leaf proteins will be extracted from the various fodder plants by the method of Chibnall and Schryver. These proteins will then be incorporated into synthetic diets, so made up that the protein which it is desired to investigate will constitute the sole source of nitrogen. The minimum quantity of the protein required (*a*) to maintain the animal; (*b*) to permit growth of the animal; (*c*) to permit reproduction, will be ascertained and compared with the minimum requirements of some standard protein of high nutritive value, such, for example, as casein. If in any case a leaf protein is found to be markedly inferior to the standard protein in nutritive value, it will be apparent that some amino acid in the leaf protein is present in relatively deficient amount. An attempt will then be made to ascertain which of the eighteen or nineteen amino acids is deficient, partly by chemical examination which, however, is at present only applicable to certain amino acids, and partly by supplemental feeding tests in which amino acids are added to the diet until one is found which adequately supplements it. Bearing in mind that the cystine requirement of the sheep may probably be higher than that of laboratory animals, a series of such tests should enable us to define with certainty the degree of amino acid deficiency encountered in the leaf proteins of Australian fodders.

The practical measures to be adopted on the basis of this information will depend upon the nature of the deficiency found, and the means which may suggest themselves of correcting it. Unfortunately, our knowledge of leaf proteins from this point of view is limited, and this lack of knowledge applies not only to Australia, but to the rest of the world. As time goes on, however, it may be possible to ascertain that the leaf proteins from some plant capable of introduction to the area concerned may adequately supplement the existing natural fodders. Another means of combating deficiencies when found would be to broadcast concentrated foodstuffs containing proteins specifically chosen to supplement the fodder proteins.

A second part of the investigations upon laboratory animals will consist of administering to them, as outlined above, excess of certain mineral salts, particularly magnesium and potash, and ascertaining in such animals their requirements of other minerals, particularly lime, phosphoric acid, and sodium.

The third avenue of research upon laboratory animals will consist of a detailed investigation of the utilization of phosphoric acid by animals, with the particular object of throwing light upon the hitherto unsolved problem of the relative proportion in which phosphoric acid may be employed by the animal for building up tissue derivatives of phosphoric acid, such as lecithin, nucleic acid, and so forth, on the one hand, and for the construction of bone, on the other. Nucleic acid is not less essential than protein for the building up of tissue, and it is uncertain in what form phosphoric acid must be present in the diet, whether free or in the form of organic compounds, to enable the manu-

facture of this substance. If nucleic acid were produced in inadequate amount there is reason to believe that the whole of the growth and development of the animal would be seriously retarded. The conditions leading up to the manufacture of nucleic acid in the animal body are as yet very imperfectly understood, and it will be our object to throw some further light upon them.

(ii) *Field Investigations upon Sheep.*—It is proposed to ascertain the relationship between weight and age of sheep in various typical pastoral districts, and at the same time to correlate these results with the production and quality of the wool. In this way we will obtain an idea, first, of what constitutes a normal average sheep in the districts concerned, and, secondly, of the deviations from this average which may be expected in any one district, and between different districts. On charting these weight-age data, it will probably be found that the growth-curve of the sheep displays characteristics which we can correlate with the nature of its surroundings. As we eventually accumulate data regarding the fodder plants, stock waters, and underlying geological formations in these districts, it will probably be possible to correlate definite deformations of the growth-curve with definite fodder, soil, water, or climatic conditions. Furthermore, we can ascertain by these means at what age the animal most particularly suffers from a given deficiency, that, of course, being the age at which correction of the deficiency will be most essential.

In order to furnish some sort of control upon these field results, and provide an ideal standard with which we can compare that which is particularly attainable, a small flock of sheep will be maintained at the Waite Institute, under the joint supervision of Professor A. E. V. Richardson and myself. These sheep will be kept in pens and hand-fed, and their requirements for (*a*) maintenance, (*b*) growth, (*c*) reproducton, and (*d*) wool production upon a balanced ration of known composition will be ascertained. To facilitate these inquiries a respiration calorimeter will be employed.

(iii) *Chemical Investigations.*—These will consist of:—

(*a*) *Chemical Analysis of Animal Tissues.*—It is proposed to initiate at once an iodine survey of the thyroids of Australian sheep from as many different localities as possible. The determination of iodine in herbage or water is attended by considerable difficulties, and yields results which are difficult to interpret, since we do not know whether all of the iodine in the herbage is actually available to the animal. The animal's own storehouse of iodine is the thyroid gland, and if any deficiency of iodine occurs, this will be manifested in the deficient iodine content of the gland, and also probably in its altered structure. By determining the iodine content of the thyroid therefore we are dealing with the situation as the sheep finds it, so that, irrespective of what may be the content of iodine in the herbage, if the iodine is deficient in the thyroid we know that there is not enough for the animal's requirements. These investigations will be carried out by the chemist appointed by the University of Adelaide, under the Animals Products Research Foundation, to co-operate with the Council of Scientific and Industrial Research. Simultaneously my colleague, Professor C. S. Hicks, proposes to examine the thyroids histologically, confirming the iodine estimations by observations of the concurrent alterations of structure.

In the second place, it is proposed to carry out a series of analyses of the nucleic acid content of laboratory animals at various ages, and upon the various diets employed, with a view to ascertaining the influence of age and diet upon the synthesis of nucleic acid in the animal body. The results of this inquiry, of course, will bear directly upon the problem of the utilization of phosphates.

(*b*) *Chemical Analyses of Plant Tissues.*—These will be conducted at the Waite Institute, under the supervision of Professor A. E. V. Richardson, and the joint direction of the Empire Marketing Board and the Council for Scientific and Industrial Research.

4. Description of the Laboratory.

The laboratory which has been planned for the purpose of these investigations measures 100 x 54 feet, and is two stories high. It will be provided with central heating for the animal rooms, and the furnace will be accommodated in a small basement room. Besides offices and laboratories for the workers on the chemical aspects of the problems, there will be two large suites of rooms designed to accommodate rats and mice respectively. The total number of laboratory animals which it is proposed to employ in this building will be about 8,000. For the purpose of maintaining so large a number of animals in health, a considerable staff, most exact hygienic supervision, and kitchens and machinery for the preparation of large volumes of food will be necessary. The cages for rats will be of the design employed by Motteram; those for mice a design which has been evolved in this laboratory as the result of many years' experience. Wheeling tables will be provided to facilitate the moving of animals and food. A room in each suite will be devoted to sterilization of cages and food containers; another to storage of foodstuffs; and another to their preparation.

An important feature of the building will be the chart-room, in which the growth-charts of the laboratory animals and of the sheep investigated in field experiments will be filed in such a way as to permit immediate access to and display of the charts. Adjacent to the chart-room will be a filing room, in which all the records, both of laboratory and field experiments, will be filed in card index form. It will be the duty of a special officer to constantly keep these up to date, and to apply to the data thus recorded statistical methods of computation which will enable us to ascertain precisely what degree of reliance we can place upon the various quantitative estimates that we may obtain in our investigations.

It will be understood that the foregoing statement embodies merely an outline of a tentative programme, and that we must be prepared to undertake other problems as necessity arises, or as the growth of our knowledge suggests other important avenues of inquiry. The relative emphasis placed upon the different aspects of the investigation may also be varied from time to time.

In conclusion, it is hoped that, in the course of some years, the dovetailing of these various lines of inquiry may afford us a solid foundation of fact upon which to build an improved economic practice in the future.

Co-operative Research in the Wool Industry.

Memorandum received from the British Research Association for the Woollen and Worsted Industries.

In 1916, the British Government placed a sum of £1,000,000 at the disposal of the Department of Scientific and Industrial Research to enable it to encourage industries to undertake research themselves. The policy of the Department is to delegate the prosecution of industrial research on a co-operative basis to the industries themselves, working through voluntary associations of firms engaged in producing similar articles, or using the same materials. Twenty-five Industrial Research Associations have been established. They receive annual contributions from the fund on a £1 for £1 basis with membership subscriptions. The whole question of Australian membership of these Research Associations will be discussed by the Chairman of the Council (Mr. G. A. Julius) during his present visit to England. The following memorandum has been received from the Research Association for the Woollen and Worsted Industries.—ED.

The Prime Minister, in a speech in the House of Commons on unemployment, condensed a widely accepted view when he made use of the following words:—

> "No one will assert that British industry can be saved by science alone, but it is none the less true that, until scientific methods and scientific men can take their place in industry and an equal place with the administrator and the financier, British trade will never be strong or resilient enough to meet the shocks that it is bound to meet as the years go by, or to meet the sudden and unexpected changes which will always arise in international trade."

We find to-day a growing co-operation between the Universities and the Research Associations. The researcher in pure science at the University has a different motive from the industrial research worker in applied science. What the American would call the "urge" is entirely personal in the case of the professor of pure science, whereas in the case of applied science the urge or motive is supplied in the growing demands of humanity. Applied science is not by any means merely technical or technological work; it is impossible to follow up a carefully planned scheme of applied science without being driven into pure science.

No industrial organization can devote the whole of its attention to new things; it must attempt to improve existing things. Yet there is always a place for the new thing. Industry must place itself in the position of watching what the man in pure science is doing, and applying his results to its own ends. It is clear that any firm staffed by intelligent and experienced men will in time be able to satisfy a great many of the demands made upon it; it will learn by the process known as "trial and error" which operations are successful and which unsuccessful. Contrary to the hasty opinion of many persons, investigation by trial and error is a scientific process. Its defect is that it is slow and wasteful. It is for this reason that the British Research Association for the Woollen and Worsted Industries has been established for the co-operative study of the many difficult and varied technical problems confronting these industries, with a view to acquiring and disseminating the most recent and reliable information relating to every stage of the production of good cloth from raw wool.

The task of the Association begins with an inquiry into the nature of the wool fibre. How is a single fibre of wool produced, and upon what does its production depend? How does it behave in all the varying conditions which it is likely to meet with in its passage from the wool pack to the cloth warehouse? What is the effect on it of storage, transport, soap, moisture, alkalis, acids, dyes, or steam?

Again, what variations of the fibre should be produced for different purposes? To the ordinary observer, sheep may look more or less alike, but it is well known that there is a great deal of difference in the kinds of wool they produce, in its length, its curliness, its fineness, and in its felting qualities. Can the quality of the wool produced by any particular breed of sheep be improved by suitable crossing, or by feeding it on different soils, or in different climates? How can sheep be prevented from having patches of dead fibres which interfere with the uniformity of dyeing? What sort of sheep dips are likely to interfere least with the processes of manufacture? How shall the farmer brand his sheep in such a way that the marking persists throughout the season, but disappears readily in the scouring process?

And when the wool reaches the mill as a dirty, tangled mass of highly compressed greasy fibres, how can the impurities best be removed, and the fibres disentangled with a minimum of damage to their natural qualities, and put into an ordered state?

The objects of the British Research Association for the Woollen and Worsted Industries are: —

(*a*) To promote co-operation amongst wool producers and wool-using firms with a view to investigating the problems met with in the woollen and worsted industries.

(*b*) To co-ordinate existing means of research, and further their development.

(*c*) To avoid waste, utilize by-products, and enhance the quality and quantity of wool, and the materials into which it is manufactured; and

(*d*) To provide new uses for wool, e.g., as an insulating medium, &c., by creating new demands and widening its application.

Membership of the British Research Association for the Woollen and Worsted Industries is open to British corporations carrying on business in the production or marketing of wool, or in any process in which wool is wholly or in part used as the raw material, and those British subjects carrying on such businesses as members of a British firm.

Members of the Association have the following privileges:—

(*a*) Of benefits arising from or attributable to any results from the work of the Association.

(*b*) Any member subject to certain provisions may have special information given to, or obtained for them, by the staff of the Association, or may have special investigations or researches conducted on their behalf.

The scale of subscription at present in operation is as follows:—

Group.	Amount of Capital.	Unit of Subscription.
	£	£
A not exceeding ..	20,000 ..	5
B " " ..	40,000 ..	10
C " " ..	60,000 ..	15
D " " ..	100,000 ..	20
E " " ..	200,000 ..	30
F " " ..	400,000 ..	50
G " " ..	700,000 ..	75
H " " ..	1,000,000 ..	100
J " " ..	2,000,000 ..	200
K " " ..	3,000,000 ..	300
Z exceeding	3,000,000 ..	100 for each £1,000,000 or part thereof.

The Association was incorporated in September, 1918, and during the first five years of its existence the Department of Scientific and Industrial Research gave a grant of £1 for £1 on all subscriptions received by the Association from members. This method of assistance by the Government has now been replaced by a system of block grants on a much reduced scale.

Australian corporations and firms are eligible for membership, and it is suggested, therefore, that in the case of Australian firms being admitted to membership, the Commonwealth Government should give a similar grant of £1 for £1 on such subscriptions received. In return the Association would keep the Australian Government informed of all the results of its research work, and would be in a position to consider co-operation in any scheme of research suggested by the Commonwealth.

Commonwealth members would be given the right:—

(i) To put technical questions to the staff of the Association, and have them answered as fully as possible within the scope of the research organization.

(ii) To recommend specific subjects for research, and through the Council of the Association to have a voice in the selection of the programme of research.

(iii) To the use without charge, or on reduced terms, of any patents resulting from research.

(iv) To ask for a particular research for their sole benefit at cost price, provided this can be undertaken without detriment to the general programme.

(v) To receive confidentially, in convenient form, such results of researches as the Association decides not to publish openly.

(vi) To receive regularly the output of an information bureau devoted to the industry, and thus of being kept in touch with scientific and technical development at home and abroad.

The Australian Meat Industry: The Economic Importance of the Satisfactory Freezing of Beef.

Report prepared at the request of the Council for Scientific and Industrial Research by the Meat Freezing Committee of the Australian National Research Council (September, 1926).

At first glance it appears a curious anomaly that whereas in the principal capital cities of Australia and the southern populated districts generally beef commands a high price, over nearly one-half of the continent the prices realized for cattle are so low that profitable production, despite abundant pastures, cheap rentals, and relatively small labour requirements, is almost, if not quite, impossible. Nowhere is this illustrated to a greater extent than in the Northern Territory, where at Darwin an enormous freezing works with up-to-date equipment has been idle for six years, save for a brief period last year (1925), when boiling down operations solely were conducted, and under 10,000 head treated. As the initial expenditure by the proprietors of these works was, it is stated, over £900,000, while interest, depreciation, and maintenance cannot be estimated at less than 10 per cent. per annum, it will be seen that the position is serious.

While the future may show that a considerable portion of the best area at present devoted solely to cattle raising may prove suitable for sheep and wool production, such a change over cannot be initiated without great expenditure of capital in water supplies (particularly by boring), equipment of bores, fencing, &c. But even then there is evidence that most of the northern half of the Australian tropical belt must remain devoted to cattle raising, if not always, for very many decades to come.

Since the war the market for frozen beef has been in a state of depression. On the London market it is usually quoted at a price approximately less than one-half that of freshly killed, home-fed beef. For this there appear to be several reasons.

(1) The quality of our beef, prior to freezing, is not equal to that of the locally grown (British) fresh beef. This is not a matter for surprise. British beef cattle are on the whole better bred; they are reared in very small paddocks, and are either fattened in buildings or small enclosures, receiving artificial or specially prepared fattening rations. This means a tenderer meat, with the fat more evenly distributed, not only between the muscles, but throughout the muscle structure, which itself in a "prime" carcass is in a condition, strictly speaking, of fatty degeneration. The facilities for rapid marketing in Britain also obviate any deterioration between the farm and the abattoir. On the contrary, the bulk of Australian cattle reared and fattened for export as beef are depastured on large areas; they are more or less always on the move in grazing and travelling to and from waters; and, in addition, after fattening they have to travel long distances to rail, thence suffer a trying journey to the point of slaughter, all of which has a deleterious effect on the flavour and tenderness of the meat.

(2) There is another fact which operates in favour of the freshly-killed meat. It is well known that meat subsequent to death of the muscle and before putrefaction can set in undergoes certain changes, particularly in the muscle-plasma (or juice), due to enzymes; these

changes are termed autolysis. They improve the quality from the consumer's stand-point. The longer meat can be hung after slaughter, and prior to cooking, the better. Now the enzymes which cause the "ripening" (autolysis) and the consequent improvement, although present in the plasma of frozen beef, are rendered inert or practically so at a low temperature, particularly near or under the freezing point. Australian beef killed for export in the frozen condition has usually little opportunity for these autolytic changes to occur. Shortly after slaughter the meat is placed in a chamber maintained at little above 32 deg. F., and cooled down as rapidly as possible. When this chamber is filled, the meat is transferred to the freezing rooms where it is hard frozen as quickly as possible. Those autolytic changes that do occur prior to freezing have not been determined, but there is evidence they have made little progress. When the meat reaches the retailer it is seldom more than partially thawed, and accordingly it is safe to say by the time it reaches the cook, the condition, so far as the "ripening" process is concerned, is not much better than when it left the killing floor. Neither the retailer nor the consumer have the space nor the time to permit the changes to take place. It is quite likely that the rapid cooling undergone by artificially chilled beef, and the short time which usually elapses before it is cooked after removal from the chill room, preventing the "ripening," has a good deal to do with the marked difference between the wholesale price of even the best chilled beef from the Argentine and that of fresh killed meat on the London market.

(3) Independent of these factors, it is now generally recognized that beef suffers certain deleterious changes during the process of freezing, and to some slight extent during thawing, changes that are not so manifest or so serious in the case of mutton and especially lamb subjected to the same treatment. These changes have been carefully, though not yet fully, investigated by the Food Investigation Board of the British Department of Scientific and Industrial Research, and by this (A.N.R.C.) Committee *vide* its special reports. While it is evident that definite changes in the composition of the muscle plasma occur, there are other alterations in the structure due to the pressure of large ice crystals which form between the muscle cells, these being greater in size the more prolonged the latent period of freezing. As it seems probable, from our observations, and from practical knowledge of the different effects on lamb and on sheep muscle, that the age of the cell wall (or sarcolemma) may have an important bearing on the extent of the permanent damage arising from the pressure exerted by the forming ice crystals, it is proposed to investigate this question in the series of experiments which has been outlined by the Committee.

Preservation by Chilling versus Freezing.

During recent years the Argentine Republic has been exporting more and more of its beef in a chilled condition.

The following table shows the exports of each class for the past five years in tons:—

	Frozen Beef.	Chilled Beef.
1921 ..	225,230 ..	158,571
1922 ..	132,223 ..	263,836
1923 ..	207,743 ..	364,662
1924 ..	325,230 ..	388,599
1925 ..	253,962 ..	393,233

It will be observed that the ratio between the frozen and the chilled product varies considerably. This is due to the fact that only the best quality beef, especially that which has been topped off on rich lucerne pastures, is chilled, the second grade being frozen, the lower qualities canned. It is much more expensive to store and especially to ship chilled beef than frozen, for obviously quarters of the former cannot be stacked one on top of the other as can the latter. Hence freights for chilled beef are considerably higher than for frozen beef.

In this connexion it is well to remember that the Argentine pastoralist has, for the past 30 years, been consistently improving the beef quality of his cattle by the extensive use of pure-bred bulls. Indeed, for many years the high price prevailing in Britain for pure-bred bulls of the beef-producing breeds, such as the Shorthorn, Aberdeen-Angus, and Hereford, has been mainly due to the regular Argentine demand. The Australian cattle pastoralist on the contrary has done little or nothing towards the improvement of his herds, either by drastic culling, or the provision of high-class bulls. One is not surprised, therefore, to find that the Argentine frozen beef is generally quoted at a price slightly over the Australian, the average difference during 1925 being ½d. per lb. for hindquarters. (See W. Weddel and Company's last Annual Review).

As to whether a trade in Australian chilled meat could be developed or not, and whether, if so, it would prove an economic improvement, one cannot decide with certainty. There are, however, certain factors which indicate that such a development would be risky and unprofitable at present—

(i) Very little of the Australian beef available for export is equal in quality to Argentine chilled.

(ii) Although one small shipment of chilled meat has been landed in satisfactory condition after a prolonged voyage,* experiments and experiences alike have shown that retention of beef in a chilled state for longer than six weeks is attended with some degree of risk. This is the minimum duration of the voyage from the last port in Australia to a British port. Prior to shipment a fortnight must be allowed for after slaughter, and a further delay of at least a week between arrival and retail in England, all of which accentuates the risk of deterioration. As against this, Argentine is but three weeks' journey from London.

(iii) Then there is the multiplicity of freezing works in Australia. Generally not one could alone supply a full shipment of chilled beef. On the other hand, the Argentine works are close together on the La Plata River, and the latest to be erected has a killing capacity of about 4,000 cattle per day, or nearly two-thirds that of all the freezing works in Australia. All this facilitates the economical working of the Argentine chilled beef trade.

(iv) There are other elements which increase the economic risk. Chilled meat, even that from the Argentine, has to be disposed of for the reasons adduced, as soon after its discharge from the ship as possible. Local weather conditions and quantities arriving influence

* Since the preparation of this report two other small shipments of chilled beef have been sent by private interests from Australia to London. In the first of these the meat was not landed in a very satisfactory condition; in the second it reached its destination in good condition, and sold well. In the latter case, however, it is reported that the temperatures used were low and the meat was almost soft frozen.—Ed.

prices materially, and render them erratic. This is well illustrated by W. Weddel and Company in their Review for 1925. They state:—

> "*Chilled Beef.*—Quotations for chilled hindquarter beef pursued their usual erratic course throughout the year, the chief factors governing prices being the weather (which affected the demand) and the quantity of meat pitched day by day. Although the supplies available were not less than in the preceding year, and the quality of the meat was certainly no better, the average level of chilled beef prices was considerably higher than in 1924. For the first six months the quotations fluctuated round about 7d. per lb., but in July, August, and September a higher level was reached, due to curtailment of the shipments as a result of the shortage of fat cattle during the Argentine winter. The average price during this period was about 7¾d. From the middle of October, however, to the end of the year, except for two weeks in November, prices ruled on a much lower scale, the average being in the neighbourhood of 6¼d. A jump of 1½d. for the Christmas trading brought the closing quotation for the year up to 7¾d."

Quotations for frozen beef naturally fluctuated considerably throughout the past year, but the average difference between the prices of Argentine frozen hindquarters and chilled was only 1½d. per lb. When one bears in mind the greater cost of production, and particularly of freight, added to a certain degree of risk, chilling as a solution of the Australian beef producers' difficulties does not seem to be promising.

In reviewing the economic situation, it is well, perhaps, to look nearer home than South America, wherein conditions in regard to labour and other costs are quite different to those existing in Australia. New Zealand offers a better field of comparison. The Commonwealth is, roughly, 30 times the size of the Dominion, with rather more than five times the population to feed. It has less than four times the number of cattle (13,050,000 to 3,500,000) and less than four times the number of sheep (83,620,000 to 24,540,000). New Zealand has a larger proportion of its cattle devoted to dairying than has Australia.

As already pointed out, the cattle raising industry (exclusive of dairying), throughout the greater part of Australia, is conducted under the most primitive of conditions. The largest stations have little or no fencing, save the horse paddocks at the homesteads; in many instances water supplies are only those provided by nature in lagoons and billabongs, although in Western Queensland and parts of the Barkly Tableland (Northern Territory) there has been a large expenditure on boring and equipment; and the amount of white labour required on such properties is small, often not one per 500 square miles, the aborigine being a useful stockman with supervision. Mustering, branding, marking, and droving are the expensive operations, the last being a serious item on outlying properties.

In New Zealand, on the contrary, all the cattle are bred and fattened in paddocks, generally comparatively small in area, and on English grasses. No property being far from a railway or a freezing works, transport to the latter is easy and cheap in comparison with droving and transport in Australia. Otherwise labour and oversea freight costs are on a par in both countries. Yet Australia did not export quite double the frozen beef that the Dominion did in 1923 (60,926 tons to 36,736 tons), nor two and a half times the quantity in 1921 (74,853 tons to 32,413 tons), although last year her exports were

about three and a half times in excess (123,393 tons to 35,300 tons). The total quantity of frozen meat (beef, mutton, and lamb) exported by New Zealand is generally much in excess of the total export of Australia, as is the total exports of dairy produce; but that does not concern our present discussion. What does concern us is the fact that the New Zealand cattle-owner still seems to find the production of beef for export, frozen, an economic possibility. Here it would be well to point out that the quality of the frozen beef exported is on a par with the Australian, judging by market quotations; very few of the dairying class of cattle are fattened for either local consumption or for export as frozen quarters.

Notwithstanding these facts, the consensus of opinion is that cattle raising in Australia is not a profitable enterprise. The reasons for this are as difficult to determine as it is to suggest a remedy. Extension of railway facilities would certainly assist some properties now very remote from such transport, and enable fat stock to be marketed instead of stores. But the industry at present will hardly bear costly transport of live stock. Reduction of rentals would assist in some cases, but in many they are already so low as to be comparatively unimportant. It is obvious that improvement of the quality of our beef would enhance the price somewhat, but the increase, in view of Argentine returns, would be hardly sufficient to warrant great expenditure. An improvement in the method of freezing, whereby the deterioration now caused would be obviated, so that frozen beef when cooked would equal fresh-killed, would be the most satisfactory solution. But this does not seem likely to be attained, although investigations and experiments to this end should be continued and extended as we recommend.

The opening up of fresh markets amongst the Continental peoples would assist materially, but the present indications are not hopeful of such an extension of trade; the Continental imports of frozen meat for 1925 were 10 per cent. less than for 1924 (429,100 tons and 476,800 tons respectively). Meanwhile, the herds of the world are increasing. It has been estimated that from Mexico to the "Horn" there are nearly 100,000,000 cattle. During recent years Brazil, Venezuela, and South Africa have become exporters, while Canada now ships live store cattle (last year the numbers being 110,000), in addition to an increasing export of chilled beef. The beef cattle in the United States, on the other hand, are decreasing, the reduction of this class in 1925 compared with 1924 being 24 per cent. (See Weddel's last report). But that republic is not yet an importer. Immature beef (baby beef) is being more and more utilized as a food supply. In any case the neighbouring States, Mexico and Canada, will supply all her wants for many years to come.

It is evident that every effort should be made to stimulate the cattle industry of the North. It is the only industry which can be relied upon to people even sparsely nearly a third of the continent. It is not flourishing. The causes for its despondency are the low ruling prices for frozen beef. Suitable remedies are, therefore, impossible to suggest with confidence. Imperial preference in regard to meat imported by Britain would, of course, do much to stimulate the exploitation of unoccupied and occupied lands in Australia fitted mainly for cattle raising. But that is outside the scope of this Committee.

What does demand attention, however, is the disparity of prices for beef in the north and in the south. For reasons connected with the prevention of the dissemination of animal diseases there are barriers to the movement of stock between the tropical belt and the southern populous areas, mainly due to tick infestation and pleuro-pneumonia. Still, these alone should not deter the people of the south benefiting from the excess of the north. Similar barriers in regard to the transportation of live stock exist in United States of America because of the southern tick infested area. They are overcome by slaughter of cattle in the south and transportation of the beef chilled in special trucks.

In Australia similar rail transport of chilled beef from tropic to temperate zones is not practicable, because of breaks of gauge. But as all meat works are near the sea-board, and the large centres of population are similarly situated, there should be no difficulty in providing adequate transport by sea—a more economical method than by land. Naturally, certain vested interests would be affected, but within the continent the greatest benefit to the greatest number is paramount, especially in relation to food supply. Furthermore, a regular supply of Queensland chilled beef would help to stabilize the southern markets and to prevent the extreme fluctuations of price that now occur in times of scarcity.

The request of the Council for Scientific and Industrial Research for observations on the Australian meat industry in its relation to the export of frozen and chilled beef leads this Committee to venture the suggestion that an exhaustive impartial inquiry into all the circumstances and facts connected with the industry might do much to elucidate the true position, and lead to recommendations of some value, other than those which the Committee has made in its special reports.

The Committee has to thank the Chairman (Dr. Gilruth) and the Hon. W. Angliss for the preparation of this report, in which, as a body, it concurs.

The Biological Control of Prickly Pear.

Investigations of the Commonwealth Prickly Pear Board.

By Alan P. Dodd, Officer-in-Charge of the Investigations.

1. Introduction.

Prickly pears are members of the genus *Opuntia*, of the cactus family, which is native to North and South America. The genus *Opuntia* contains between 300 and 400 species, many of which have been transported to various parts of the world, and have become pests in some places, notably *O. aurantiaca* in South Africa, and *O. dillenii* in

Ceylon. But in Australia these plants have flourished in a manner truly remarkable, and the spread of *O. inermis* in particular is regarded as one of the botanical wonders of the world. At least 24 species of prickly pear are found growing wild in Australia; the origin of their introduction is unknown in most cases, but it is certain that the first prickly pear was imported from Brazil by Governor Phillip and the first colonists in 1788, the species being, probably, *O. monacantha,* which is found at scattered intervals from Melbourne to Cape York. The two main pest pears, *O. inermis* and *O. stricta,* natives of the coast of Florida and the adjacent islands, have infested 60,000,000 acres of land in Queensland and New South Wales, and the rate of increase is now estimated at roughly 1,000,000 acres a year. Of recent years, the tiger pear *O. aurantiaca,* the dreaded "jointed-cactus" of South Africa, has spread seriously.

The great problems of control of prickly pear lie in the rapid rate of its spread, the density of its growth, and the low value of the greater part of the infested lands. On good agricultural soils, the value of the land permits its destruction at a relatively economical cost. In the main, our prickly pear areas embrace the natural grass grazing country where the land is worth less than £3 per acre. A very complete investigation has been made of the possibilities of control by chemical and mechanical means; several arsenical poisons are being used extensively and profitably, but their usefulness is definitely restricted by the density of the pear infestation and the value of the infested areas.

The first step in the direction of biological control was taken in 1912, when a Queensland Travelling Commission was appointed. After eighteen months occupied in visiting various parts of the world, the Commission recommended the introduction, under safeguards, of the natural insect and disease enemies of prickly pear.

The Commonwealth Prickly Pear Board was established in June, 1920, under a scheme of co-operation by which the Commonwealth, New South Wales, and Queensland Governments agreed to make available £4,000, £2,000, and £2,000, respectively, per annum, for the investigation of the possibilities of biological control. From 1st January, 1926, the finances for the Board's work were increased to £12,000 on the same proportional basis of contribution by the respective Governments.

2. The Work of the Board.

The scope of the work includes, briefly:—

(*a*) The study of all prickly pear insects in their native country.
(*b*) The breeding of material free from parasites and predators.
(*c*) The testing of these insects against crops and other plants.
(*d*) The forwarding of selected kinds of insects to Australia.
(*e*) Their breeding and acclimatizing under local conditions.
(*f*) Their establishment in the open at various localities on our several pest pears.

There is no doubt that prickly pears in America are held in check by natural agencies; for example, in the United States alone more than 60 species of insects are primarily cactus feeders. The Board has worked on the hypothesis that if it is possible to acclimatize in Australia the natural enemies of prickly pear, then the control of the pest must follow eventually. It is its aim to introduce a complex of agencies that will attack each species of pest pear, under all conditions of growth, soil, and climate.

3. In America.

Operations were commenced in the United States in 1920, and entomologists have been employed in that country since. The cactus areas of the United States have been surveyed comprehensively. After brief scouting excursions had been made, systematic study of the Mexican cactus areas was instituted in 1926. A preliminary survey of some of the islands of the West Indies was conducted recently, and in South America the republics of Argentine and Uruguay have been studied more completely.

Being botanically rather isolated, the cactus family has evolved a very considerable insect fauna that appears restricted to plants of that group. A central breeding station has been established at Uvalde, Texas, where the insects found throughout the United States are reared and studied under cage conditions, and certain species, selected for transportation to Australia, are bred in numbers, free from their parasites and predators. An important phase of the investigation is the testing against economic plants, in order to ascertain, as far as possible, the probability of any cactus insect being able to develop on other plants. An experiment garden is maintained at Uvalde, where each kind of insect is tested on a large number and wide variety of plants. These tests have given interesting results, and more species than one have been eliminated because of the possibility of their sustaining existence on certain economic plants. The tests are repeated in Australia against economic plants and native trees. Shipments of clean stocks of insects are made in specially constructed cases which are packed with sufficient prickly pear growing in damp sphagnum moss to ensure a food supply throughout the journey. Since the beginning of the investigations, 300 cases, containing many thousands of insects, have been forwarded to Australia.

4. In Australia.

A central laboratory and quarantine station has been established at Sherwood, near Brisbane. The insects from America are here further tested against economic plants, and bred through one or more generations as an additional safeguard against the introduction of parasites that might exercise a serious check on their rate of multiplication. The material bred is then distributed to the field stations maintained at Westwood, near Rockhampton; Chinchilla, 200 miles west from Brisbane; and Gravesend, on the Moree-Inverell railway, in New South Wales. The function of the field-stations is to rear the insects in sufficient numbers to permit liberations in the open.

It has not been found possible to establish every kind of prickly pear insect imported from America. The difficulties of the investigation are manifold. One of the great problems has been the acclimatization of the insects, more especially those introduced from North America. Brought into Australia, they are faced with opposite seasonal cycles, and their behaviour is a matter of conjecture. With most insects, repeated shipments over a period of from two to three years have been necessary to secure their establishment, and certain species have failed to adapt themselves to the reversal of seasons. Another difficulty has been the rearing of insects under cage conditions. There has been no precedent for the breeding of insects in vast numbers, and experience had to be gained with respect to the type of cage, and the number of insects to a cage that would yield the best results with each

species. Moreover, there was the problem of the handling of large stocks of insects by a staff limited by financial stringencies. The rearing of insects requires constant supervision; under confined cage conditions, disease epidemics are liable to break out and destroy the patient work of months and years. Another phase of the work has been the study of the adaptability of the various insects to Australian prickly pears. The degrees of preference displayed by an insect toward closely related prickly pears is an interesting problem. Very few cactus insects will attack all prickly pears indiscriminately. Most show a decided partiality for certain forms, and may readily attack one pear, and refuse to live on an allied species. Among the cochineals, this preference is developed to a very high degree.

5. Field Experiments.

After each insect has been introduced, acclimatized, and bred in sufficient numbers, field experiments are conducted with the object of:—

(*a*) Deciding how it will adapt itself to local field conditions;
(*b*) Ascertaining ways and means of effectively carrying out liberations;
(*c*) Learning the destructive effect on the pear; and
(*d*) Endeavouring to establish bases or nuclei of supplies at various places.

As a purely experimental body, the Board has not undertaken wholesale distribution, although in some cases the quantities of an insect released embrace very large numbers. Distribution is a matter for the respective States, and both in Queensland and New South Wales, State organizations have undertaken the spread of cochineal on a comprehensive scale. These two States are now co-operating with the Board on a scheme whereby it is anticipated very large quantities of other insects will be bred and distributed.

6. The Insect Enemies of Prickly Pear.

For convenience, the insect enemies of prickly pear can be divided into the following groups:—

(*a*) The internal feeding or tunnelling caterpillars of various moths (*Lepidoptera*).
(*b*) The internal feeding grubs of various beetles (*Coleoptera*).
(*c*) The plant-sucking bugs (*Hemiptera*).
(*d*) The cochineal and other scale insects (*Homoptera*).
(*e*) The fruit enemies of various kinds.
(*f*) The prickly pear red spider (*Tetranychus*).

7. The Internal Feeding Caterpillars.

The boring caterpillars constitute one of the largest and most important group of insects; species occur everywhere in North and South America. As a rule, each species is restricted to certain types of Cactaceae. The caterpillars are frequently gregarious in habit, living in social colonies of from 20 to 100 within the plant, and are often highly coloured. In the genera *Melitara* and *Cactoblastis*, the moths have the peculiar habit of depositing their eggs in chains or egg-sticks, the first egg being attached to a spine of the plant, the remainder being firmly fixed, one below another, to form a continuous outline. The number of eggs in an egg-stick varies, and different species average

greater or smaller numbers per stick; thus those of *Melitara junctolineella* contain from 8 to 20, while those of *Cactoblastis* may contain as many as 150 eggs per chain, with an average of about 75.

Melitara junctolineella, from Texas, represents a group whose larvae are solitary for most of their existence. Acclimatized in Australia in 1923, some 1,250,000 insects have been liberated. The species is firmly established in several localities in Queensland and New South Wales, and is increasing in a satisfactory manner. It is, however, an insect of minor importance. In the spring generation the caterpillars destroy fruit and young growth. Throughout the year, seedling plants are killed, and older joints may be destroyed to a noticeable extent.

Melitara prodenialis, a native of Florida, is typical of a group whose larvae are greyish-blue to intense blue in colour, and are social in habit. There are three broods annually. It was acclimatized in 1923, and thrives on the "spiny" pest-pear *O. stricta* of Central Queensland. Liberations of 200,000 caterpillars near Rockhampton yielded very destructive effects on *O. stricta* plants in a few weeks. The severe drought of 1926, however, has seriously retarded the progress of this important insect. Up to the present, *M. prodenialis* has shown little partiality for the common pest-pear *O. inermis.* In the more arid regions of the United States occur three related forms, *Melitara hollii, M. doddalis,* and *M. dentata.* Each possesses one generation annually, and is capable of causing very considerable destruction to prickly pears. The establishment of these desirable moth-borers has not yet been accomplished in Australia.

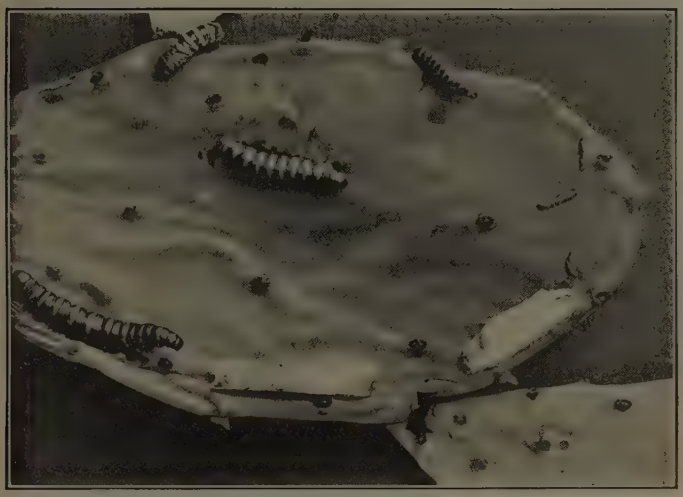
Easily the most important of the moth-borers is *Cactoblastis cactorum.* In fact, it can be considered the most destructive prickly pear insect discovered up to the present. Three thousand young larvae were forwarded from the Argentine in March, 1925. Twelve months later, after the lapse of two generations, this number had been increased in Australia to 2,500,000. The caterpillars, bright orange or red in colour, with black cross-bands, are extremely partial to *O. inermis,* readily destroy *O. stricta,* and are very destructive to the tiger-pear *O. aurantiaca.* Ten million larvae have been released throughout Queensland and New South Wales. The liberations have shown most gratifying results, and, in most cases, the increase has been very marked. The caterpillars tunnel through the pear, frequently bringing about complete eradication of the plants. It is anticipated that very large numbers of this insect will be distributed within the next three years.

The larvae of *Mimorista flavidissimalis,* a small yellow moth from Texas, destroy the young growth. Several liberations have been made, but apparently have failed to secure establishment. Another large social moth-borer *Laniifera cyclades,* from Mexico, is now being studied with the object of introduction.

8. The Internal Feeding Beetle Grubs.

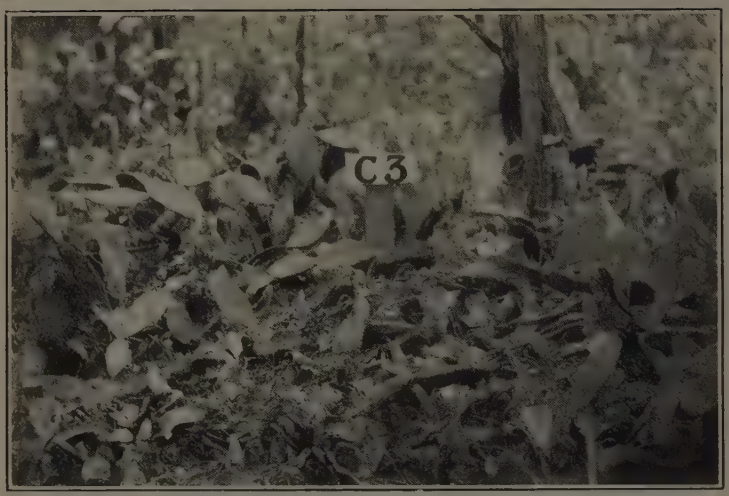
Of the beetles that attack prickly pear the most important are the wingless longicorns, of the genus *Moneilema,* of which many species occur in the United States and Mexico. The large white larvae tunnel in the basal parts of prickly pear, and are capable of causing much destruction. Several species have been introduced in numbers, but have proved difficult to rear in cages. However, *Moneilema ulkei* is now being successfully bred at Westwood, and appears to be established in the field.

PLATE 1.



Melitara junctolineella—Larvae and cocoons. (See page 52.)

Chelinidea Vittiger. (See page 53.)



Photograph of Prickly Pear at Chinchilla, Queensland, showing damage done in two years after infestation with Red Spider and Cochineal.

Same as above, showing destruction six months later (March, 1927).

Photograph of Prickly Pear showing the destruction caused by *Cactoblastis cactorum*.

Same as above (closer view) six months later (March, 1927). The further destruction is the work of the second generation.

Photograph of Prickly Pear on the Lilydale-road, Westwood, Queensland. The photograph was taken in July, 1924. The Pear had been infected with Texas Cochineal (*Dactylopius tomentosus*) in April, 1923.

Same as above (closer view) taken in October, 1926. The Pear has been practically all destroyed.

In the United States, several species of small weevils of the genus *Gerstaeckeria* are of minor importance, but in Mexico the large weevils of the genus *Cactophagus* are serious enemies of prickly pear.

9. The Plant-Sucking Bugs.

Four species of plant-sucking bugs of the genus *Chelinidea* occur in the United States and Mexico. Three of these, *C. tabulata, C. vittiger,* and *C. canyona* were acclimatized in 1921-23. *Canyona* has made little progress. *Vittiger* has increased well in cages, but liberations, totalling 20,000 bugs, have shown no increase, except in one experiment in Central Queensland. *Tabulata,* however, has thrived under Australian conditions. About 100,000 have been released throughout Queensland and New South Wales, and in many localities the species now abounds in millions. For example, from a liberation of 100 bugs near Dulacca, Queensland, it is estimated that the number now present must exceed 100,000,000.

Where these bugs occur in quantity, the fruit and young growth may be destroyed very largely, while the older joints become yellow and sickly from their attack, do not remain sufficiently healthy to produce new growth and fruit, and are more susceptible to onslaughts by other insects.

10. The Cochineal Insects.

The most widely known of prickly pear insects are the cochineals—soft-bodied scale insects protected by a woolly covering—that feed on the fruit and joints of prickly pear. Three forms of the wild cochineal *Dactylopius tomentosus* are established in Australia, viz., the Chico strain introduced by the late Mr. Temple Clerk, and the Texas and Arizona strains introduced by the Board. All three will live on the two chief pest pears, but the virulence of their attack varies. The Chico form is most destructive to *O. inermis,* and the Texas form favours *O. stricta,* but the three strains are equally destructive to the tree-pear *O. tomentosa.* These cochineals have been widely distributed throughout the two States, and are now flourishing everywhere. They are performing splendid service in many places, especially in dense pear in timbered areas, breaking up the plant masses, and eradicting old plants. Probably the most useful feature of their work is the manner in which they destroy young seedlings.

The Indian Cochineal, *Dactylopius indicus,* was introduced by the Queensland Prickly Pear Travelling Commission in 1913, and has now practically wiped out the scattered areas of the smooth tree-pear *O. monacantha.* This cochineal will not attack our other pest-pears.

Another cochineal, *Dactylopius newsteadi,* has proved almost equally destructive to the "Devil's rope," *O. imbricata,* which occurs in scattered quantities in New South Wales and Southern Queensland.

11. Fruit Enemies.

Although many insects destroy prickly pear fruits, several are primarily fruit feeders. Of these the most important is the seed-midge, *Asphondylia opuntiae,* from North America, whose life-history is peculiarly adapted to its host plant. In the United States, frequently

from 75 to 100 per cent. of the fruits of prickly pear may be destroyed by this little fly. Unfortunately, the acclimatization of *Asphondylia* presents many difficulties, and has not yet been accomplished.

12. The Prickly Pear Red Spider.

This insect, *Tetranychus opuntiae,* was introduced from Texas in 1924. It has spread in remarkable fashion, and has infested many thousands of acres of prickly pear. The tiny mites feed on the surface of the pear, causing the formation of a corky layer whose growth brings about the destruction of the joint. The attack is of a sudden nature, and is much more rapid than that of cochineal. Many acres of dense pear may be reduced to a state of partial collapse in a few weeks, and the plants appear incapable of recovering from the onslaught. Although quite different in its mode of attack, red spider is equally as important as cochineal; together these two insects form a harmonious combine by which there is every reason to believe that the dense areas of *O. inermis* in heavily timbered country will be eradicated.

13. The Diseases of Prickly Pear.

Prickly pears are attacked by various fungoid and bacterial diseases, but these have played little part in the control of pear in Australia. In America, however, there are several important diseases affecting prickly pear. In 1925, the Board appointed a research scholar in mycology, who is undertaking the study of various diseases with the aim of introducing them into Australia.

Conclusion.

The Board has succeeded in its object of establishing American prickly pear insects in Australia. Each year further insect pests will become established, and wider distribution will be accomplished. The investigation of the possibilities of biological attack has altered the hopeless attitude from which the control of prickly pear was formerly viewed. There is every reason to believe that, as the insects multiply and spread, the area covered by the pest will gradually diminish, and the land be reclaimed for pastoral and agricultural purposes.

NOTES.

Buffalo-fly Pest.

Following on the report which the Council obtained in 1926 from its investigator (Mr. D. Murnane, B.V.Sc.) as to the prevalence and distribution of the buffalo-fly in the northern parts of Australia and as to the extent to which it is spreading (see page 18), inquiries were sent to entomological authorities in the Philippines, the Dutch East Indies, and the Hawaiian Isles asking whether they could arrange for investigations to be carried out on behalf of the Council with a view to ascertaining whether there are any natural enemies which destroy the buffalo-fly in any stage of its life history in the respective countries. The replies which were received in response to these inquiries have been submitted for the consideration of a Committee, consisting of Dr. J. A. Gilruth (Chairman), Dr. Georgina Sweet, Professor H. A. Woodruff, and Mr. G. F. Hill.

In accordance with the recommendations of that Committee, advice is now being sought from Dr. G. A. K. Marshall, Director of the Imperial Bureau of Entomology, as to the practicability of securing a consignment of *Hydrotaea dentipes,* which in its larval stage lives on the larvae of the stable fly and the house fly, and which may therefore reasonably be expected to parasitize also the larvae of the buffalo-fly. Dr. Marshall is also being asked for advice as to the prospects of establishing *H. dentipes* in Australia and, in the event of it being successfully established, as to the possibility of it becoming a pest of economic animals or plants.

The Council has also decided to avail itself of an offer made by Dr. B. Maaesmach, Director of the Veterinary Institute, Buitenzorg, Java, to arrange for a study to be made of the natural enemies of species of buffalo-fly in that country, under the control of Dr. O. Nieschulz. Information is also being sought from appropriate authorities in the British and foreign Colonies and Protectorates in Africa and from the Imperial Entomologist, India, as to the economic status of species of buffalo-fly in their respective countries and as to the prospects of securing natural enemies suitable for transportation to Australia.

From the information already obtained by the Council it is evident that the buffalo-fly is a very serious pest in certain parts of Northern Australia, that it has spread over considerable areas during recent years, and that, with the opening up of additional railway lines and other means of transport, there is a grave danger of the fly spreading further, especially in the north-eastern parts of the continent. Observers in Australia have expressed the view that if the fly reaches Queensland it may well prove to be an even more serious menace to the cattle industry than the cattle-tick pest has proved to be.

The Council, therefore, views the position with very considerable concern, and is anxious to take all steps practicable to carry out scientific investigations with a view to the control of the buffalo-fly and preventing its further spread. It appears, however, that control by natural enemies is the only method which is likely to lead to satisfactory results.

Poison Plants Investigation.

Arrangements have been completed for an investigation of poison plants, which are alleged to cause heavy losses of stock in Australia, by the Council in co-operation with the University of Sydney and the New South Wales Department of Agriculture. In order to advise it as to the manner in which the investigation is to be conducted, the Council has appointed a Committee, consisting of Professor J. Kenner, F.R.S. (Chairman), Professor H. G. Chapman, Dr. H. R. Seddon, Mr. Max Henry, Dr. G. P. Darnell-Smith, Mr. H. Finnemore, and Professor T. G. B. Osborn. The Council will provide the necessary funds estimated at from £1,000 to £1,250 per annum. There will be three main divisions of the investigation—(*a*) chemical, (*b*) veterinary, and (*c*) pharmacological.

The co-operative scheme of investigation is as follows:—

1. The Council agrees:—
   - (*a*) To appoint a Committee to advise it regarding the manner in which the investigation is to be conducted, such Committee to be composed of the leading investigators in charge of the several sides of the work. This Committee will report direct to the Council, and through it to the University and the State Department.
   - (*b*) To provide the sum of £1,000 for expenses (including salaries) during the financial year 1926-27.
   - (*c*) Thereafter to provide funds for the investigation on the remendation of its Executive Committee and subject to Ministerial approval.
   - (*d*) Subject to the approval of its Executive Committee to publish the results of the investigation as may from time to time be desirable.
2. The University agrees:—
   - (*a*) That Professor Kenner, Professor Chapman, and Mr. H. Finnemore may act on the controlling Committee, and that the ordinary facilities of University Departments will be at their disposal in the work which they respectively undertake.
   - (*b*) To permit officers of the Council engaged on the investigation under the gentlemen named to work in, and to use all the ordinary facilities of the Departments of Chemistry and Pharmacology, it being understood that while within University boundaries such officers are subject to the discipline of the University.
3. The Department of Agriculture of New South Wales agrees:—
   - (*a*) That Dr. Seddon, Dr. Darnell-Smith, and Mr. Max Henry may act on the controlling Committee, and that Dr. Seddon may supervise that part of the work which will be conducted at Glenfield.
   - (*b*) To make the normal facilities at Glenfield available for the work.
4. The officers will be appointed by the Council subject to the approval of the University and the Department of Agriculture.
5. The co-operative arrangement will be continued wih such modifications as may from time to time be deemed necessary, until such time as it may be terminated by general consent, or by twelve months' notice in writing from one of the associated parties.

Poison Plants of the Northern Territory.

An interesting attempt has recently been made to eradicate poison plants from an important stock route in the Northern Territory. For a number of years a certain portion of the main route between Wycliffe Wells and Taylor Crossing, along which thousands of head of cattle have to pass every year in order to reach the southern markets, has been known as the poison zone. During the droving season of 1923 an average of 20 animals out of every 100 died of some kind of poisoning on the road. The actual cause was not known, although it appeared more than probable that it was due to some poison plant that the stock grazed as they passed through. The losses became so serious that stock-owners appealed to the Commonwealth Government for help through the Department of Home and Territories, and it was arranged that Professor A. J. Ewart, University of Melbourne, should make an expedition to the infected area, and endeavour to ascertain the cause of the trouble, and to suggest remedial measures. It was also arranged that Professor Ewart should be assisted by Mr. Bishop, Chief Veterinary Inspector of the Northern Territory, and Sergeant Stott, of the Alice Springs Police Force, both of whom were well acquainted with the district. Almost at once Professor Ewart placed two plants under suspicion—one a sage bush (*Isotroposis atropurpurea*), and the other an indigo plant (*Indigofera boviperda*). He experimented with them on some stock that had been taken with the expedition for that purpose, and proved conclusively that both were extremely poisonous. He inspected the whole poison zone, and found that sage bush and, to a lesser extent, indigo plant were plentiful throughout, and that they appeared to be spreading rapidly, probably as a result of the frequent burnings which occur along the route.

On returning to Melbourne, Professor Ewart urged that an attempt should be made to clear these two plants from all along the route before the stock began to travel.

In March, 1925, it was arranged that Sergeant Stott, who had previously been instructed by Professor Ewart in identifying the plants and in the best methods of cutting and destroying them, should gather a party of aboriginal labourers and the necessary equipment and proceed north. The party did excellent work, clearing at an average of 2 miles per day. They cut and burnt every plant of sage or indigo to a distance of 75 yards on each side of the telegraph line. They also erected notices at intervals, informing stockmen that this had been done, and advising them to keep their beasts within the cleared area. The work occupied a period of only 21 days, and the total cost was less than £150. The success of the enterprise has been gratifying, and the so-called poison zone has now practically disappeared. In 1926 a mob of 3,000 cattle passed over the area without a single casualty. In fact, for the last two years no deaths have been recorded in stock travelling between Wycliffe Wells and Taylor's Crossing. This year it has again become necessary to go through the area, pull the seedlings that have appeared, and cut off the plants that have grown from the old roots. The labour involved will not be nearly as arduous as the original clearing, and if it is done about every two years it is probable that the time will come when poison bush will be unknown in the district.

Standing Committee on Agriculture.

On page 14 reference is made to a conference which the Council convened in March last to advise as to what place the Commonwealth could best fill in the field of agricultural research and as to how co-operation in that field between the Commonwealth and the States should be effected. The conference recommended that in order to secure the necessary co-operation and collaboration, the Council should appoint a Standing Committee on Agriculture, consisting of the permanent Heads of the State Departments of Agriculture and of representatives of the Council, such Standing Committee to act as the advisory and consultative body on matters relative to agricultural and live-stock research undertaken by the Commonwealth.

Effect was given to this recommendation, and the first meeting of the Standing Committee was held in Adelaide on the 25th May last, when the following were present:—

Permanent Heads of the State Departments of Agriculture—

Dr. S. S. Cameron, Victoria (Chairman).
Mr. G. D. Ross, New South Wales.
Mr. E. Graham, Queensland.
Professor A. J. Perkins, South Australia.
Mr. G. L. Sutton, Western Australia.
Mr. F. E. Ward, Tasmania.

Representatives of the Council—

Professor T. G. B. Osborn, University of Adelaide.
Professor J. Prescott, Waite Agricultural Research Institute.
Professor A. E. V. Richardson, Waite Agricultural Research Institute.
Professor A. C. D. Rivett, Executive Committee of Council.
Mr. G. A. Cook (Secretary).

The more important matters dealt with by the Standing Committee were as follow:—

(*a*) *Quarterly Journal.*—With regard to the proposal made by the Agricultural Conference, that the Council should publish a Journal of Scientific Research, the Standing Committee decided that the Council's Quarterly Journal would meet the requirements of the States for the time being.

(*b*) *Tobacco Investigations.*—The scheme of work, of which an outline is given on page 16, was approved by the Committee.

(*c*) *Imperial Institute.*—Consideration was given to a despatch proposing that the Imperial Institute should act as a clearing-house of information on all subjects connected with the development and utilization of raw products throughout the Empire. The proposal would involve the Departments of Agriculture preparing half-yearly reports on the progress of their researches. The Standing Committee considered that the preparation of the proposed information half-yearly would be inconvenient and undesirable. It was arranged that the Heads of the State Agricultural Departments should send letters to the Director of the Imperial Institute explaining the difficulties in the way of furnishing special half-yearly reports, but promising to furnish copies of all publications issued by their respective Departments.

(*d*) *Poison Plants.*—The co-operative scheme of investigation, regarding which information is given elsewhere in these Notes, received the hearty commendation of the Committee.

(*e*) *Imperial Conference on the Co-ordination of Agricultural Research.*—The action taken by the Council regarding representation of the Commonwealth at this Conference and the preparation of information for the use of the Conference was explained to the Committee, and was approved. Information regarding this matter is also given elsewhere in these Notes.

It was provisionally agreed that the next meeting of the Standing Committee be held in January next, or shortly after the return of the Australian delegates to the Imperial Agricultural Research Conference.

Agricultural Research—A Clearing House of Information.

The Agricultural Conference convened by the Council in March last (see page 14) was of the opinion that the Council could render a valuable service to the agricultural institutions of the Commonwealth by acting as a clearing-house for information on research projects in progress in Australia.

Action is accordingly being taken to compile a register of agricultural research in progress throughout the Commonwealth. For that purpose copies of forms will be sent to the State Agricultural Departments and other institutions concerned asking for information regarding each research project to be furnished with respect to the following:—

1. Names of principal investigator and chief assistants.
2. Place where work being carried out.
3. Title and objects of investigation.
4. Co-operation (if any) with other bodies.
5. Progress of work.
6. Impediments, if any, to progress of work.

The State Agricultural Departments and other institutions concerned will also be asked to suggest subjects for investigation either by the Council itself or by the Council acting in co-operation with the States. When the desired returns are received a register will be compiled, and a copy of it sent to each of the Departments and other institutions concerned. In this way it is hoped, not only that the Council will be able to render a valuable service by acting as a clearing-house of information, but also that specific suggestions will be forthcoming as to the problems on which the Council can usefully undertake research work. The whole position can then be fully discussed at the next meeting of the Standing Committee on Agriculture.

Imperial Conference on the Co-ordination of Agricultural Research.

Towards the end of 1925, the question of the co-ordination of agricultural research throughout the Empire engaged the attention of the Agricultural Research Council of Great Britain. As a result, it was recommended that a Conference of representatives of all parts of the Empire be held in the autumn of 1927. This proposal was considered

by the Imperial Conference of 1926, which fully endorsed it, and urged the respective Governments concerned to give their fullest possible support.

The Conference will accordingly be held in London, commencing on the 4th October, 1927, and lasting for about a month subsequent to that date. Its main purpose will be the consideration of machinery for securing effective co-operation in agricultural research throughout the Empire. The questions coming up for discussion will, therefore, be such as the following:—Should the system of bureaux now exemplified by the Bureaux of Entomology and Mycology be extended to other branches of agricultural science? By what methods of publication, circulation, &c., can the progress of and results of research best be made available throughout the Empire? How far can the supply and training of scientific workers be organized on an Imperial basis? What arrangements should be made for the interchange of workers in the different parts of the Empire?

Australia will be represented at the Conference by three representatives, as follow:—Mr. G. A. Julius, Chairman, Council for Scientific and Industrial Research; Dr. S. S. Cameron, Director, Victorian Department of Agriculture; and Professor A. E. V. Richardson, Director, Waite Agricultural Research Institute. Mr. Julius will be in London on other business, but Dr. Cameron and Professor Richardson are going specially for the Conference.

Astronomical Work in Australia.

On several occasions in recent years the Commonwealth Government has been approached by various organizations in regard to the astronomical work carried out in Australia. The Australian National Research Council has also interested itself in the matter, and has received communications from Great Britain, in which attention is drawn to the delay which has occurred in Australia in the fulfilment of certain astronomical obligations of an international nature, particularly those relating to the compilation of the Astrographic Catalogue.

In order to obtain advice on the whole position, the Council convened a meeting in March last of the leading Federal and State Astronomers of Australia. This Conference was of the opinion that the Commonwealth should take a more active interest in astronomical work, but at the same time it indicated that the present State Observatories should preserve their present entities. A feeling was also expressed that the Observatories should be associated with their respective Universities. The findings of the Conference were considered subsequently at a meeting of the full Council, and the above-mentioned opinions of the Conference were endorsed. It was also recommended that if the Commonwealth decided to take any action along the lines suggested, an eminent authority on astronomy should be invited to visit Australia, and to report on the best means of carrying out the suggestions.

Maintenance of Standards in Australia.

Under the Act constituting the Council, the functions of the latter include the testing and standardization of scientific apparatus and instruments, and of apparatus, machinery, materials, and instruments used in industry; and the carrying out of scientific investigations connected with standardization. In order to obtain advice on these matters, the Council, towards the end of 1926, convened a Conference of the Heads of the more important Australian physical laboratories. The Conference advised that the progress of Australia, its efficiency in industry, and the effectiveness of its defence system would be handicapped if some of the facilities which other countries have in the shape of their National Physical Laboratories were not made available in Australia in the near future. The Conference felt, however, that the idea of immediately establishing an Australian National Physical Laboratory should be rejected chiefly on the grounds that, in some respects, it would be an unnecessary duplication of personnel and equipment already existing in other Australian laboratories, and that the cost of its establishment would amount to a large sum. The Conference advised further that to render effective the extensive and valuable work of the Australian Commonwealth Engineering Standards Association, and to provide for the sound development of technical and industrial work in Australia, it was almost imperative that immediate action should be taken in regard to the question of legal standards.

This advice has been considered by the Council, which has now formed a Committee in order, *inter alia*, that further action on matters relating to the maintenance of standards in Australia might be taken. The present constitution of the Committee is as follows:—

Professor J. P. Madsen (Chairman), University of Sydney.

Professor O. U. Vonwiller, University of Sydney.

Marcus Bell, Esq., Superintendent, Research Laboratories, Defence Department.

N. A. Esserman, Esq., Research Laboratories, Defence Department.

The Committee has been formed quite recently, and but one meeting only has as yet been held.

Australian Radio Research Board.

In November, 1926, the Council convened a fairly representative Conference for the purpose of obtaining advice as to the need for a Radio Research Board in Australia. The Conference was attended by delegates drawn from the Postmaster-General's Department, the Defence Department, Universities, and broadcasting interests. It was of the opinion that the establishment of such a Board would be of advantage to all radio interests in Australia; that the primary function of the Board should be to originate, facilitate, and co-ordinate radio research investigations; and that the Board could with advantage direct its attention to (*a*) co-operation with the British Radio Research Board, and with the International Union for Scientific Radio-Telegraphy; (*b*) consideration of scientific problems

related to broadcasting in Australia; and (*c*) the improvement of equipment and other facilities available in Australia for electrical measurements at radio frequencies.

The resolutions of the Conference were approved at a subsequent meeting of the Council, when it was recognized that the chances of success of any Board that might be formed would be very considerably enhanced if it received the full co-operation of the Departments of Defence and of the Postmaster-General. On it being ascertained that these latter Departments would welcome the formation of a Board, the latter was formally constituted. The present members are as follows:—

Professor J. P. Madsen (Chairman), University of Sydney.

Professor T. H. Laby, University of Melbourne.

H. P. Brown, Esq. (Secretary), Postmaster-General's Department.

Electrical-Commander F. G. Cresswell, Department of Defence.

Professor Madsen intends making a private visit to Europe and America at an early date. He will obtain the most recent information available, and take preliminary steps in the direction of arranging an effective liaison with other countries.

Pastoral Research—New Proposals.

Important proposals for the initiation of further research into the problems of the pastoral industry were made at meetings of representative bodies of that industry, held in Adelaide towards the end of June, 1927. Proposals for research, particularly certain suggestions that had been made by the Chairman of the National Council of Woolselling Brokers, Mr. G. Aitken, had been discussed by individual members of the industry for some time previously.

In June, however, the Graziers' Federal Council of Australia carried a resolution in favour of pastoral research in general. A few days later the matter was again discussed at a combined meeting of the Australian Woolgrowers' Council (President, Sir C. Graham Waddell) and the National Council of Woolselling Brokers. On that occasion a description of the nutritional investigations he was undertaking on behalf of the Council for Scientific and Industrial Research was given by Professor Brailsford Robertson, and Australian animal diseases and research were discussed by Professor H. A. Woodruff. The individual members present also visited the Waite Agricultural Research Institute, where Professor A. E. V. Richardson outlined the work that was being done on the mineral deficiencies of pastures (see page 38).

At the combined meeting, Mr. Aitken elaborated his ideas, and they were supported by Sir Graham Waddell and others. It was finally resolved as follows:—

"That a fund be raised by voluntary subscription to provide means and facilities for research, and other scientific activities and agencies for the improvement of methods and conditions in the pastoral and grazing industry throughout the Commonwealth of Australia, particularly in regard to diseases affecting stock (e.g. the fly pest); rabbits and other animal pests; edible plant life and harmful plant life; and any other object which will lead to the advancement of the pastoral industry."

"That a Committee be formed from amongst the members of the Australian Woolgrowers' Council and the National Council of Woolselling Brokers for the purpose of obtaining contributions to such fund."

"That an incorporated body to be called "The Australian Pastoral Research Trust Limited," be constituted, and registered for the purpose of receiving such fund from the Committee, and administering the same; and that the fund shall be invested by the company in authorized trust investments, and the income applied for such purposes set out above, provided that any excess corpus over £200,000 may also be used for such purposes if deemed necessary."

The Committee mentioned above has now been formed, and has commenced its consideration of preliminary details. The individual members constituting it are as follow:—*Australian Woolgrowers' Council.*—New South Wales: Sir Graham Waddell, W. W. Killen, Esq.; Queensland: William Kent, Esq., A. J. B. McMaster, Esq.; Victoria: the Hon. M. Wettenhall, G. D. Kelly, Esq.; South Australia: E. A. Brooks, Esq., A. E. Hamilton, Esq.; Western Australia: E. Lee Steere, Esq., T. McQuire, Esq.; Tasmania: R. C. Field, Esq., B. H. Edgell, Esq. *National Council of Woolselling Brokers*—New South Wales: Frank Young, Esq., K. de L. Cudmore, Esq.; Victoria: G. L. Aitken, Esq., R. T. Boyne, Esq.; Queensland: A. Jeffray, Esq., T. McIlwraith Taylor, Esq.; South Australia: Horsley Chapman, Esq., T. Cheadle, Esq.; Western Australia: J. J. Mahood, Esq., S. A. Hunn, Esq.; Tasmania: George Cragg, Esq., Gerald Roberts, Esq.

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